A Handbook of the MOSQUITOES of the SOUTHEASTERN UNITED STATES

By
W. V. King
G. H. Bradley
Carroll N. Smith
and
W. C. McDuffie

Agriculture Handbook No. 173

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

PRECAUTIONS WITH INSECTICIDES

All insecticides are potentially hazardous to fish or other aquatic organisms, wildlife, domestic animals, and man. The dosages needed for mosquito control are generally lower than for most other insect control, but caution should be exercised in their application. Do not apply amounts in excess of the dosage recommended for each specific use.

In applying even small amounts of oil-insecticide sprays to water, consider that wind and wave action may shift the film with consequent damage to aquatic life at another location. Heavy applications of insecticides to ground areas such as in pretreatment situations, may cause harm to fish and wildlife in streams, ponds, and lakes during runoff due to heavy rains. Avoid contamination of pastures and livestock with insecticides in order to prevent residues in meat and milk.

Operators should avoid repeated or prolonged contact of insecticides with the skin. Insecticide concentrates may be particularly hazardous. Wash off any insecticide spilled on the skin using soap and water. If any is spilled on clothing, change immediately. Store insecticides in a safe place out of reach of children or animals. Dispose of empty insecticide containers. Always read and observe instructions and precautions given on the label of the product.

UNITED STATES DEPARTMENT OF AGRICULTURE

Agriculture Handbook No. 173

A Handbook of the MOSQUITOES of the SOUTHEASTERN UNITED STATES

By
W. V. King
G. H. Bradley
Carroll N. Smith
and W. C. McDuffie

This Handbook replaces Miscellaneous Publication No. 336, The Mosquitoes of the Southeastern States, but contains information that originated in that publication.

Washington, D. C. Issued November 1960

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 75 cents

PRECAUTIONS WITH INSECTICIDES

All insecticides are potentially hazardous to fish or other aquatic organisms, wildlife, domestic animals, and man. The dosages needed for mosquito control are generally lower than for most other insect control, but caution should be exercised in their application. Do not apply amounts in excess of the dosage recommended for each specific use.

In applying even small amounts of oil-insecticide sprays to water, consider that wind and wave action may shift the film with consequent damage to aquatic life at another location. Heavy applications of insecticides to ground areas such as in pretreatment situations, may cause harm to fish and wildlife in streams, ponds, and lakes during runoff due to heavy rains. Avoid contamination of pastures and livestock with insecticides in order to prevent residues in meat and milk.

Operators should avoid repeated or prolonged contact of insecticides with the skin. Insecticide concentrates may be particularly hazardous. Wash off any insecticide spilled on the skin using soap and water. If any is spilled on clothing, change immediately. Store insecticides in a safe place out of reach of children or animals. Dispose of empty insecticide containers. Always read and observe instructions and precautions given on the label of the product.

UNITED STATES DEPARTMENT OF AGRICULTURE

Agriculture Handbook No. 173

A Handbook of the MOSQUITOES of the SOUTHEASTERN UNITED STATES

By
W. V. King
G. H. Bradley
Carroll N. Smith
and W. C. McDuffie

This Handbook replaces Miscellaneous Publication No. 336, The Mosquitoes of the Southeastern States, but contains information that originated in that publication.

Washington, D. C. Issued November 1960

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 75 cents

CONTENTS

Grateful acknowledgment is made of the assistance of the following people in preparing this publication: A. W. Lindquist, J. A. Fluno, Alan Stone, A. D. Cushman, Lola J. Roos, Della Sims, and Lucy Ford.

A HANDBOOK OF THE MOSQUITOES OF THE SOUTHEASTERN UNITED STATES

By W. V. King, G. H. Bradley,[1] Carroll N. Smith, and W. C. McDuffie, entomologists, Entomology Research Division, Agricultural Research Service

This publication deals with the mosquitoes recorded from the nine States east of Texas and Oklahoma and south of the latitude of the Virginia-North Carolina border, bringing together information that is widely scattered through the literature, and providing a convenient means of identification. It constitutes an extensive revision of a previous publication (*193*), the third and last edition of which was issued in 1944. As in that publication, it contains notes, brought up to date, on the habits of the species, their distribution, economic importance, and methods of collection and control, with brief descriptions of the species and keys for the identification of adults and larvae. Considerable material has been added, particularly on methods of control and on bionomics. Because fewer species are considered than in the more general reference works, an effort has been made to simplify the identification of adults by using for generic separation principally those characters that can most readily be seen.

GENERA AND SPECIES FOUND IN THE SOUTHEASTERN STATES

The mosquitoes found in the Southeastern States comprise a fairly natural group as most of the species in this country are either restricted to the South, or reach their greatest abundance there. The general distribution and status as to prevalence and economic importance are shown in table 1. The information has been compiled from records in the literature and from collections of the present writers.

The following species are listed as being of economic importance:

Anopheles quadrimaculatus, the common malaria mosquito, transmits malaria and is an annoying pest as well.

Aedes aegypti, the yellow-fever mosquito, is a vector of yellow fever and dengue fever, as well as a troublesome house pest.

Culex pipiens quinquefasciatus, the southern house mosquito, is a serious house pest. It transmits bird malaria and is an intermediate host of some of the filariae.

[1] Now with the United States Public Health Service.

TABLE 1.—*Genera and species of mosquitoes occurring in nine Southeastern States, and their relative prevalence*

Genus and species	Occurrence recorded in—									Prevalence and importance[1]
	Florida	Georgia	Alabama	Mississippi	Louisiana	Arkansas	Tennessee	North Carolina	South Carolina	
Aedes:										
aegypti	+	+	+	+	+	+	+	+	+	1
atlanticus	+	+	+	+	+	+	...	+	+	2
atropalpus	...	+	...	...	...	+	+	+	+	4
canadensis canadensis	+	+	+	+	+	+	+	+	+	2
canadensis mathesoni	+	+	+	...	...	...	...	...	+	4
cinereus	+	+	+	+	+	+	+	+	+	4
dorsalis	...	...	...	+	+	...	...	...	...	4
dupreei	+	+	+	+	+	+	+	+	+	4
fulvus pallens	+	+	+	+	+	+	+	+	+	4
grossbecki	...	...	...	+	+	+	+	...	...	4
infirmatus	+	+	+	+	+	+	+	+	+	2
mitchellae	+	+	+	+	+	+	+	+	+	4
scapularis	+	...	...	...	...	...	...	...	...	4
sollicitans	+	+	+	+	+	+	...	+	+	1
sticticus	+	+	+	+	+	+	+	+	+	4
stimulans	...	...	...	+	...	...	...	...	...	4
taeniorhynchus	+	+	+	+	+	+	...	+	+	1
thelcter	+	...	...	...	...	...	...	...	...	4
thibaulti	+	+	+	+	+	+	+	+	+	4
tormentor	+	+	+	+	+	+	...	+	+	4
tortilis	+	...	...	...	...	...	...	...	...	4
triseriatus	+	+	+	+	+	+	+	+	+	2
trivittatus	...	+	...	...	+	+	+	+	+	4
vexans	+	+	+	+	+	+	+	+	+	2
Anopheles:										
albimanus	+	...	...	...	...	...	...	...	...	4
atropos	+	+	+	+	+	...	...	+	+	4
barberi	+	+	+	+	+	+	+	+	+	4

Table 1.—Continued.

Genus and species	Occurrence recorded in—									Prevalence and importance[1]
	Florida	Georgia	Alabama	Mississippi	Louisiana	Arkansas	Tennessee	North Carolina	South Carolina	
Anopheles (continued):										
bradleyi	+	+	+	+	+	...	...	+	+	4
crucians	+	+	+	+	+	+	+	+	+	3
georgianus	+	+	+	+	+	...	...	+	+	4
perplexens	+	+	...	...	...	...	+	+	...	4
pseudopunctipennis	...	...	...	+	+	+	+	...	...	4
punctipennis	+	+	+	+	+	+	+	+	+	4
quadrimaculatus	+	+	+	+	+	+	+	+	+	1
walkeri	+	+	+	+	+	+	+	+	+	4
Culex:										
atratus	+	...	...	...	...	...	...	...	...	4
bahamensis	+	...	...	...	...	...	...	...	...	4
erraticus	+	+	+	+	+	+	+	+	+	3
iolambdis	+	...	...	...	...	...	...	...	...	4
mulrennani	+	...	...	...	...	...	...	...	...	4
nigripalpus	+	+	+	+	+	...	+	+	+	3
opisthopus	+	...	...	...	...	...	...	...	...	4
peccator	+	+	+	+	+	+	+	+	+	4
pilosus	+	+	+	+	+	...	...	+	+	4
p. pipiens	...	+	+	+	...	+	+	+	+	4
p. quinquefasciatus	+	+	+	+	+	+	+	+	+	1
restuans	+	+	+	+	+	+	+	+	+	3
salinarius	+	+	+	+	+	+	+	+	+	2
tarsalis	+	+	+	+	+	+	+	...	+	4
territans	+	+	+	+	+	+	+	+	+	3
Culiseta:										
inornata	+	+	+	+	+	+	+	+	+	3
melanura	+	+	+	+	+	+	+	+	+	4

Table 1.—Continued.

Genus and species	Occurrence recorded in—									Prevalence and importance[1]
	Florida	Georgia	Alabama	Mississippi	Louisiana	Arkansas	Tennessee	North Carolina	South Carolina	
Deinocerites:										
cancer	+	...	...	...	...	...	...	...	...	4
Mansonia:										
indubitans	+	+	...	...	...	...	...	...	...	2
perturbans	+	+	+	+	+	+	+	+	+	1
titillans	+	...	...	...	...	...	...	...	...	4
Orthopodomyia:										
alba	...	...	+	+	+	...	+	+	...	4
signifera	+	+	+	+	+	+	+	+	+	4
Psorophora:										
ciliata	+	+	+	+	+	+	+	+	+	2
confinnis	+	+	+	+	+	+	+	+	+	1
cyanescens	+	+	+	+	+	+	+	+	+	4
discolor	+	+	+	+	+	+	+	+	+	4
ferox	+	+	+	+	+	+	+	+	+	2
horrida	+	+	+	+	+	+	+	+	+	4
howardii	+	+	+	+	+	+	+	+	+	4
johnstonii	+	...	...	...	...	...	...	...	...	4
longipalpis	...	...	...	...	+	+	...	...	...	4
pygmaea	+	...	...	...	...	...	...	...	...	4
signipennis	...	...	...	...	...	+	+	...	...	4
varipes	+	+	+	+	+	+	+	+	+	2
Toxorhynchites:										
rutilus rutilus	+	+	...	...	...	...	...	...	+	4
rutilus septentrionalis	+	+	+	+	+	+	+	+	+	4

Table 1.—Continued.

Genus and species	Occurrence recorded in—									Prevalence and importance[1]
	Florida	Georgia	Alabama	Mississippi	Louisiana	Arkansas	Tennessee	North Carolina	South Carolina	
Uranotaenia:										
lowii	+	+	+	+	+	+	...	+	+	4
sapphirina	+	+	+	+	+	+	+	+	+	3
Wyeomyia:										
haynei	+	...	+	...	...	...	...	+	+	4
mitchellii	+	...	...	...	...	...	...	...	...	4
vanduzeei	+	...	...	...	...	...	...	...	...	4
Total	67	54	51	53	53	49	46	52	53	

[1] 1 = important economic species; 2 = locally abundant and annoying, principally out of doors; 3 = common species, not very troublesome; 4 = usually rare or of very restricted distribution.

Aedes sollicitans, the salt-marsh mosquito, is the most important salt-marsh species generally in the Eastern and Southern States.

Aedes taeniorhynchus, the small, black, salt-marsh mosquito, is another salt-marsh species of economic importance, especially in Florida.

Psorophora confinnis, the Florida glades mosquito, is an important fresh-water species in southern Florida, and is troublesome as well in other areas.

Mansonia perturbans, the common *Mansonia,* is a severe pest in areas where suitable breeding conditions occur.

Most of these species are known to be capable also of transmitting other diseases, especially encephalitis.

The woods mosquitoes, taken collectively, are also serious pests of man and animals. The principal ones in the Southeast are *Aedes triseriatus, A. infirmatus, A. atlanticus, A. vexans, Psorophora ferox,* and *P. ciliata. Culex salinarius* is important at times, and various other species, such as *P. cyanescens, P. varipes, A. canadensis,* and *Mansonia indubitans,* become very annoying in restricted localities.

Thirteen species and subspecies have been added to the list published by King *et al.* (*193*) and one, (*Wyeomyia smithii*), has been dropped as a misidentification. This brings the net total of mosquitoes definitely known to occur in the Southeast to 77. Among the different States the greatest increase in recorded species has occurred in Florida, where 16 have been added. Of the present total of 67 in that State, 15 are tropical species, only one of which has been recorded elsewhere in the Southeast. Five of the Florida species are known at present only from the Keys, and one of these, *Culex mulrennani,* described as new in 1948 (*18*), is known only from that location. The other new species, *Wyeomyia haynei* and *Psorophora longipalpis,* and one subspecies, *Aedes canadensis mathesoni,* have been described from other parts of the Southeast. *Anopheles albimanus* has apparently become established on the Florida Keys, and another species of *Anopheles, A. perplexens,* which was previously considered to be a variant of *A. punctipennis,* is now listed as a distinct species. Eight species are recorded in Georgia, Alabama, and Mississippi which have not yet been found in Florida. One species is listed only in Louisiana and Arkansas and another, only in Arkansas and Tennessee.

LITERATURE ON MOSQUITOES

The literature on mosquitoes is exceedingly large, and the articles have appeared in widely scattered publications. General reference works covering the mosquitoes of the United States are, however, comparatively limited. Of the references that include the southeastern species, the four-volume monograph by Howard, Dyar, and Knab (*163*) contains detailed descriptions, a large number of illustrations, and much information on bionomics and distribution of the species of the western hemisphere. The systematic part of this work was later extensively revised and condensed by Dyar (*96*).

Matheson's handbook (*213*) (revised in 1944) has long been a standard text and reference work on the mosquitoes of North America. It contains brief descriptions of the genera and species,

and keys for their identification, numerous anatomical illustrations, an explanation of the taxonomic terms in use, and condensed accounts of mosquito biology, their relation to human welfare, the problem of mosquito reduction, and instructions for their collection and study. A small volume by Carpenter *et al.* (*69*) on the mosquitoes of the southern United States covers the same area as that termed the Southeastern States in the present and preceding publications. A more recent volume by Carpenter and LaCasse (*68*) features full-page illustrations by Japanese artists of the females of most of the species of North America, north of Mexico. These illustrations were originally published by Yamaguti and LaCasse (*335*) in four processed volumes, and have appeared also in a small volume published privately by Yamaguti (*334*). Bates (*20*) has published a volume on the natural history of mosquitoes, and Horsfall (*160*) has summarized a considerable amount of the world literature on the bionomics of mosquitoes. Edward's valuable catalogue of the mosquitoes of the world (*102*) is now out of date, but is still a standard reference on nomenclature and classification. A Synoptic Catalog of the Mosquitoes of the World, by Alan Stone, K. L. Knight, and Helle Starcke, (*298a*) was published in 1959 by the Entomological Society of America (Thomas Say Foundation). Agriculture Handbook No. 182 by Gjullin *et al.* (*126a*) describes the mosquitoes of Alaska.

Publications of the New Jersey Agricultural Experiment Station on the mosquitoes of that State (*142*; *292*) have been of use to southern workers as they contain information on a number of species that occur in the South. The early report of John B. Smith (*292*) contains a great many original observations on mosquito bionomics. This report has been reprinted by Headlee (*145*).

A discussion of the bionomics and ecology of Nearctic *Anopheles* has been published by Bradley and King (*49*), and their distribution and classification were given in articles by King and Bradley (*190, 191*). Two works by Boyd (*34, 36*) on malariology contain much information on the natural history of anophelines and their relation to the transmission of malaria. Herms and Gray (*148*) deal with practical phases of mosquito control, and Covell (*81*) published a review of the literature prior to 1931 on the control of *Anopheles*. Two short papers on engineering aspects of mosquito control have been issued, one by the National Malaria Committee (*233*) and another by the Engineering News-Record (*104*). A monograph of the mosquitoes of medical importance throughout the world, profusely illustrated with the diagnostic characters, has been published by Foote and Cook (*114a*). Two useful pamphlets have been issued by the American Mosquito Control Association, one on the use of aircraft (*2*) and one on ground equipment and insecticides for mosquito control (*3*). United States Department of Agriculture Circular 977 (*310*) contains much information on the chemistry of insecticides and repellents, formulations, dosages, and equipment employed in mosquito control. The results of laboratory screening tests on more than 10,000 organic insecticides were reported in the United States Department of Agriculture Agricultural Handbook 69 (*186*). This included tests of mosquito larvicides, adult sprays, and repellents.

Serial publications that contain numerous original articles on mosquitoes include Mosquito News, Proceedings of the New Jersey

Mosquito Extermination Association, Proceedings of the Florida Anti-Mosquito Association, Proceedings of the California Mosquito-Control Association, Proceedings and Symposia of the National Malaria Committee (discontinued in 1941), Journal of the National Malaria Society (1942 to 1951), and Insecutor Inscitiae Menstruus (discontinued in 1926). Articles on mosquitoes appear also in the Public Health Service Reports and Bulletins, American Journal of Tropical Medicine, and its successor, the American Journal of Tropical Medicine and Hygiene, Proceedings of the Washington Entomological Society, Journal of Economic Entomology, and various other entomological and medical journals. The Review of Applied Entomology, Series B, Medical and Veterinary, is highly useful for keeping informed on the widely scattered mosquito literature of the world. Mosquito News contains a monthly list of titles of current mosquito literature which is of special value because the titles appear for the most part soon after the articles are published.

GENERAL CHARACTERISTICS AND HABITS OF MOSQUITOES

Mosquitoes are small two-winged flies belonging to the Order Diptera, family Culicidae. This family was formerly considered to include related groups but is now limited to the true mosquitoes (*298*). The wings, legs, and other parts of the body are more or less covered with scales, and the mouth parts are produced into an elongate proboscis, which is employed for piercing and blood-sucking by the females of most species. The males do not suck blood. The males can usually be distinguished from the females by their bushy antennae and by differences in the length or shape of the palpi (fig. 1). In some species the male palpi and antennae

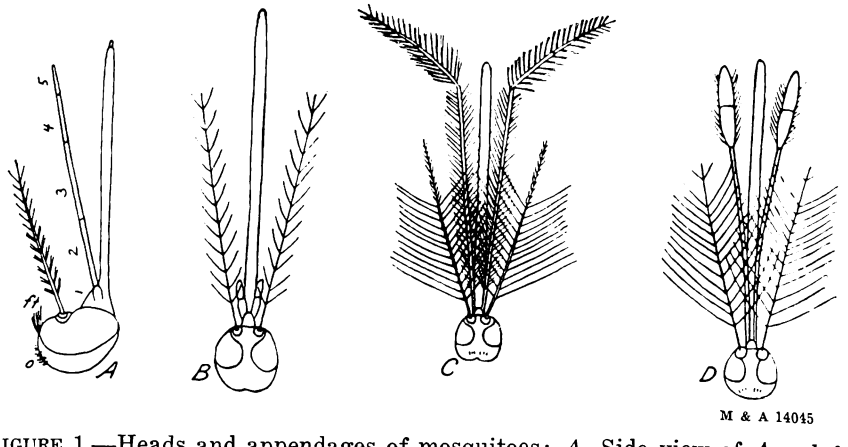


FIGURE 1.—Heads and appendages of mosquitoes: *A*, Side view of *Anopheles* female; *o*, occiput; *ft*, frontal tuft; 1-5, palpal segments. *B*, *Culex* female (from above). *C*, *Culex* male. *D*, *Anopheles* male.

are similar to those of the female. The size of different species of mosquitoes varies considerably (fig. 2).

There are four stages in the life cycle of a mosquito—the egg,

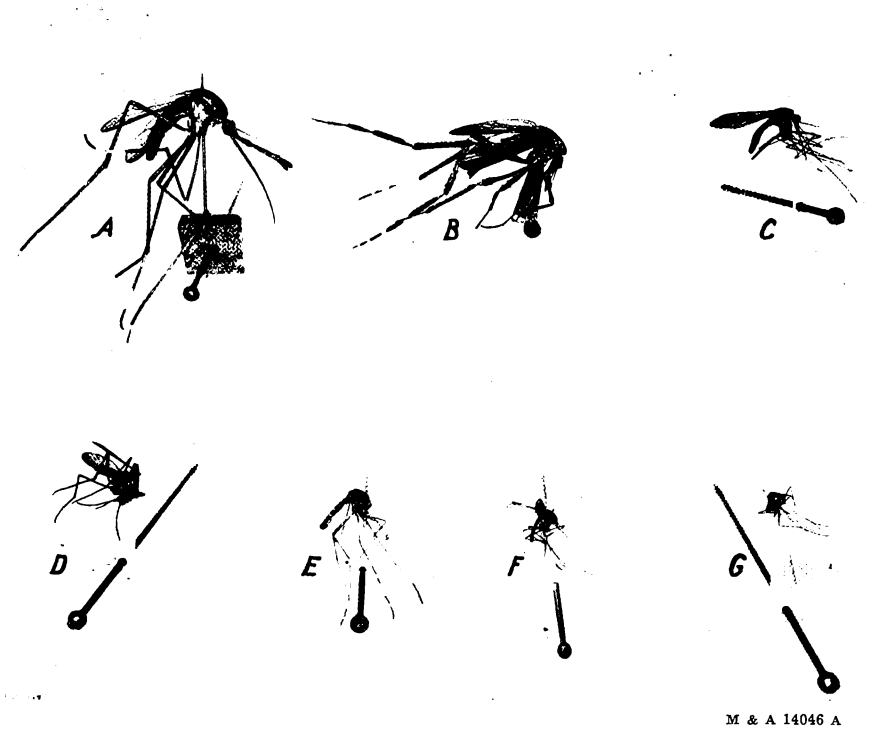


FIGURE 2.—Variations in size of mosquitoes: *A*, *Toxorhynchites rutilus*; *B*, *Psorophora ciliata*; *C*, *Anopheles quadrimaculatus*; *D*, *Aedes atlanticus*; *E*, *Culex p. quinquefasciatus*; *F*, *C. erraticus*; *G*, *Uranotaenia lowii*.

the larva (often called wiggler or wiggletail), the pupa or tumbler, and the adult winged insect or imago. The eggs mature in batches of 50 or less to 200 or more, and several such batches may be laid by one female. Among the bloodsucking species a blood meal is usually necessary for the production of eggs. When ovipositing, some species glue the eggs together into a raft or boat-shaped mass (fig. 3, *A*) which floats on the water; other species deposit the eggs singly on the water; and still others oviposit on the sides of containers above the water line, on the soil at the edge of the water, or in moist depressions (fig. 3, *B*). The eggs of *Anopheles* (fig. 3, *C*) have lateral structures that keep them afloat. The incubation period is short in warm weather (usually 2 or 3 days), but in certain species, particularly *Aedes* and *Psorophora*, the eggs are able to withstand long periods of drying; in fact, they appear to require a certain amount of drying, and sometimes exposure to cold, before they will hatch.

The larvae of all mosquitoes are aquatic and most of them free-swimming. Although possessing tracheal gills, the larvae of most species must come to the surface for air, and an elongated air tube or other modified apparatus is provided for obtaining air through the surface film. During the period of development, which lasts 4 to 10 or more days, the larval skin is shed four times, each successive instar showing a progressive increase in size. The first two instars are very small and easily recognized as immature. In the third instar the hairs have fewer branches than in the fourth

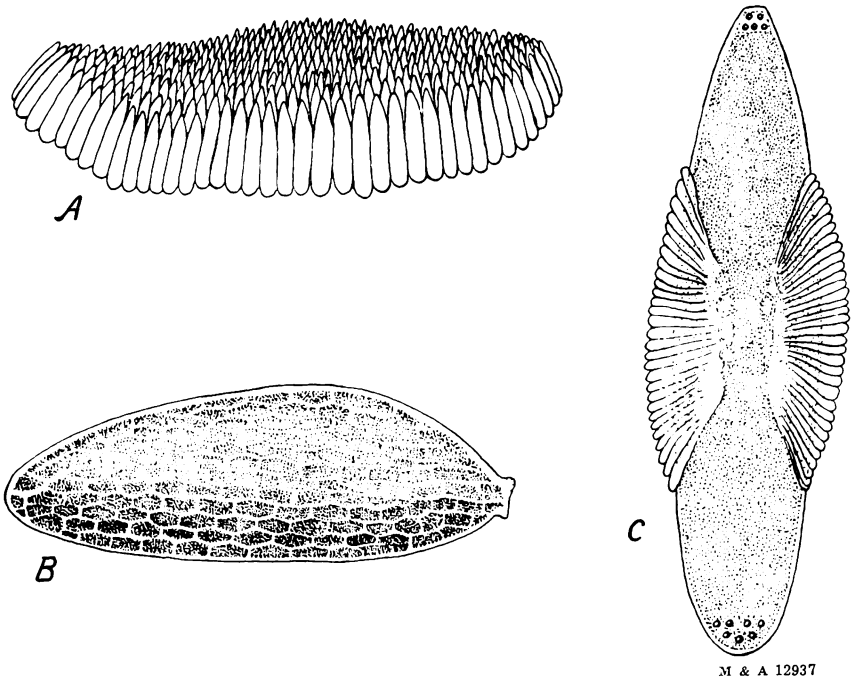


FIGURE 3.—Eggs of mosquitoes: *A*, Egg raft of *Culex restuans; B*, egg of *Aedes taeniorhynchus; C*, egg of *Anopheles quadrimaculatus*, showing floats. (Howard, Dyar, and Knab.)

instar, and the sclerotization of the anal segment is less complete. Immature *Anopheles* larvae usually have a collar of dark sclerotin around the base of the head.

The food of mosquito larvae consists of minute plants and animals and fragments of organic debris, which the larvae strain from the water by the action of their mouth parts. Barber (*9*, *10*) reared the larvae on pure cultures of various organisms, and concluded that the presence of living food organisms was necessary for any considerable growth. Hinman (*149*) has suggested that materials in solution and colloids in suspension in the breeding

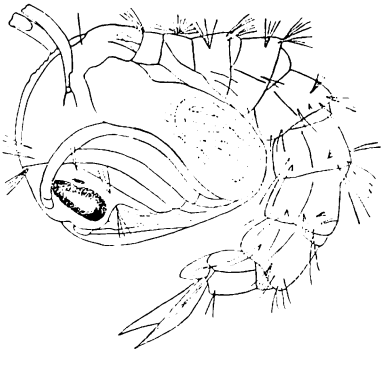


FIGURE 4.—Pupa of *Culex pipiens*. (Howard, Dyar, and Knab.)

waters may play a part in larval nutrition. A discussion of the food of anopheline larvae is given in the notes on *Anopheles quadrimaculatus*.

With the fourth molt the pupa appears. The pupal stage (fig. 4) is also aquatic and is a period of marked transformation, during which the adult insect is formed. The imago usually emerges after about 2 days.

The length of life of adult mosquitoes under natural conditions is difficult to determine, but for most of the southern species it is probably only a few weeks during the summer months. Some of the northern species of *Aedes* that emerge early in the spring apparently live much longer. Daily observations on abundance following the emergence of a large brood of certain species of *Anopheles* (*329*) and *Aedes* have shown a marked reduction in numbers within 2 weeks. The southern house mosquito probably lives longer than this, and the yellow-fever mosquito may live, on an average, a month or more, with a maximum of several months.

In the North the females of *Culex*, *Anopheles*, and some other mosquitoes hibernate. True hibernation of *Anopheles* apparently does not occur in the extreme South, as the females become active during warm periods and larvae are found in the breeding places (*6*, *14*, *40*). The same is true of some of the culicines in the warmer sections (*91*, *150*). *Aedes* and *Psorophora* pass the winter in the egg stage, although some winter development of *A. sollicitans* occurs along the South Atlantic and Gulf Coasts.

The piercing organs of the female mosquito consist of six elongated parts enclosed in a flexible sheath called the labium. When the mouth parts are inserted in the skin for bloodsucking, the sheath is bent backward in the middle like a bow. There are two pairs of slender cutting organs, the mandibles and the maxillae, and two additional organs called the hypopharynx and the labrum-epipharynx. The latter is channeled, and the last two organs, when pressed together, form a tube through which blood and other liquids are drawn. A very small separate duct is found in a ventral thickening of the hypopharynx, through which is injected the secretion from the salivary glands. This salivary secretion is responsible for the itching sensation caused by mosquito bites. Not all species of mosquitoes have bloodsucking females. In the genus *Toxorhynchites* the proboscis of the female is not adapted to piercing, and some of the species in other genera are not known to take blood meals.

The mouth parts of the male are not adapted for piercing. The males probably subsist on the nectar of flowers and fruit juices. Both the males and the females can be kept alive in the laboratory for considerable periods on fruit juices or sirups.

COLLECTION AND PRESERVATION OF MATERIAL

Anopheles larvae are usually found at the surface of the water among aquatic vegetation or floating debris and may be collected by skimming through such material with a dipper or pan. A white-enameled dipper, having the handle lengthened by the insertion of a cane or smooth stick, makes a convenient imple-

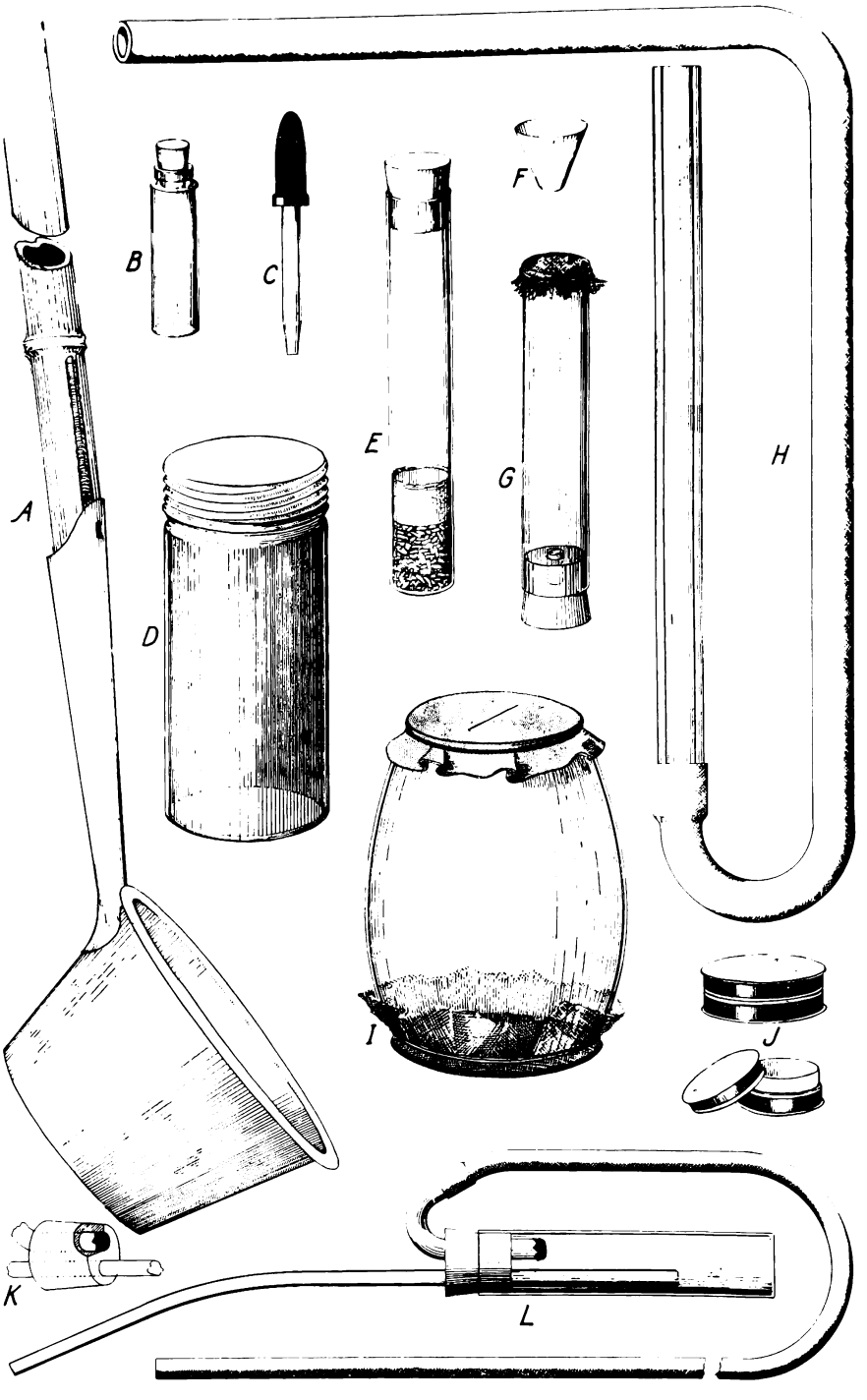


FIGURE 5.—Equipment for collecting mosquitoes. Larvae: *A*, dipper; *B*, vial; *C*, wide-mouth pipette; *D*, jar. Adults: *E*, Killing bottle; *F*, paper funnel; *G*, live tube; *H*, aspirator, straight-tube type; *I*, lantern chimney cage; *J*, paper pill boxes; *K* and *L*, aspirator and details of construction.

ment for collecting larvae. Around emergent vegetation or logs the larvae may be drawn into the dipper by submerging one edge so that the water flows in rapidly as the dipper nears the obstruction. The larvae may be removed from the dipper to the collecting jar with a spoon or a large-mouthed pipette provided with a rubber nipple (fig. 5). Wide-mouthed bottles (2 to 6 ounces) make convenient collecting jars.

Uranotaenia larvae and certain species of *Culex,* especially *C. erraticus,* are taken frequently with anophelines. Many other mosquito larvae, however, particularly those of *Aedes* and *Psorophora,* are more active and usually drop to the bottom of the pool as soon as disturbed. A quick plunge of the dipper is required to intercept these larvae, or they may be collected by sweeping through the water with a cloth collecting net or a fine-meshed wire strainer. Other kinds of mosquitoes, such as *Mansonia, Wyeomyia,* or the tree-hole breeders, require special techniques depending upon the character of the breeding places.

As soon as a collection is made, the jar should be numbered and a record kept of the locality, date, and conditions under which the larvae were found.

The larvae and pupae may be kept alive for rearing, or the large larvae (fourth instars) may be preserved for identification in 70- to 80-percent alcohol or 10-percent commercial formalin. About 1 percent of glycerin should be added if the vials are to be stored. Specimens retain their form best if killed in hot water (not over 150° F.).

Permanent slide mounts of larvae and male genitalia should be made with one of the resins such as balsam or euparol. In the U. S. National Museum, Division of Insects, permanent mounts are made rapidly with Cellosolve (ethylene glycol monoethyl ether) as the clearing agent. The larvae, from 70- or 80-percent alcohol, are partly dehydrated in 95 percent alcohol, cleared in Cellosolve, and covered with balsam after the excess Cellosolve has been removed. A modification of this technique for preparation of special study material has been described by Foote (*113*). Creosote U.S.P. is also very satisfactory as a clearing medium after rapid dehydration in 95- and 100-percent alcohol (*227*). This has been modified by employing a mixture of creosote and balsam as the mounting medium, the balsam having been heated first to drive off most of the xylene (*316*). This requires a drying period of 10 to 12 days, preferably in an incubator. Euparol may be used as the mounting medium after the use of either Cellosolve or creosote, or after dehydration in 95- and 100-percent alcohol. The formula for Berlese's chloral-gum solution, as previously recommended (*193*), provides a medium for making temporary study mounts. Unfortunately, it is not satisfactory for permanent mounts because of evaporation or deterioration. In making mounts of whole larvae it is the practice to cut the abdomen nearly in two between the 7th and 8th segments. This permits the air tube to lie flat when the cover slip is applied and exposes the lateral aspect of the 8th and anal segments.

For taxonomic study, or for identification of species difficult to determine, it is frequently desirable to have both the larval skin and the adult of the same individual. For such rearings a

nearly mature larva is isolated in a separate dish, and when pupation occurs the larval skin is removed with a pipette, spread out carefully on a slide, and a mount prepared by one of the methods mentioned above. The dish or vial containing the pupa should be covered with cloth or a larger dish, or plugged with cotton. After the adult emerges it should be kept for about 24 hours before it is killed to allow time for the sclerotin to become thoroughly hardened. The pupal skin should be mounted on the same slide with that of the larva but under a separate cover. To mount the pupal skin the cephalothorax should be detached from

M & A 10505

FIGURE 6.—Mosquito light trap.

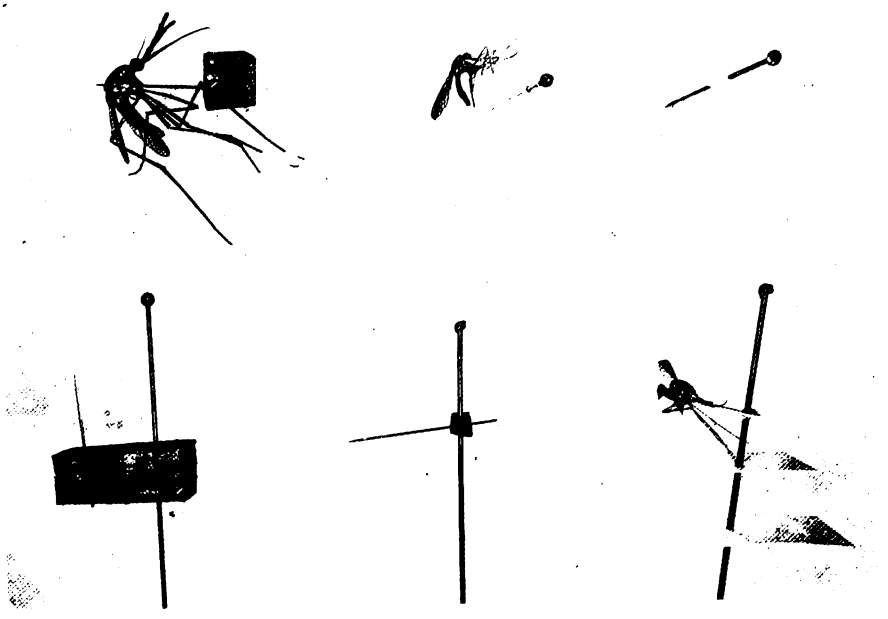
the abdomen and then opened out with dissecting needles so as to lie flat. The slide is then numbered to identify it with the reared adult.

Adult mosquitoes are usually collected while they are either biting or resting in secluded corners inside or underneath buildings, in tree holes, et cetera. A chloroform-killing tube (fig. 5) is convenient for this purpose. It may be prepared by placing a half-inch layer of cut rubber bands in the bottom of a large shell vial or test tube, saturating the rubber with chloroform, and covering with a plug of crumpled paper and a circle of stiff paper. The writers prefer a shell vial seven-eighths of an inch in diameter and about 5 inches long. When the tubes are kept tightly corked, the rubber retains the chloroform for some time. As moisture is liable to condense on the inside of the tubes, the dead mosquitoes should not be left in them long. Cyanide may also be used in the killing tubes, but it has a slower killing action and should be handled with extreme caution since it is a deadly poison to man. Several types of aspirators have been used for taking specimens alive or in large numbers. Individual mosquitoes may be kept alive in a piece of large-diameter glass tubing or a vial open at both ends. The top is covered with bobinette and the bottom is equipped with a cork in which a capillary vial is inserted to furnish water. A freshly cut raisin or wad of cotton saturated with sweetened water is placed on top of the bobinette to furnish food. A glass lantern chimney may be similarly equipped as a container for large numbers of adults. Generally the bottom is covered with a sheet of thin rubber and a ½-inch slit in the rubber permits the collector to add adults to the chamber by blowing through the aspirator. The simple tube type of aspirator is the most useful for adding specimens through the slit.

A pill box, with a thin layer of cotton pressed down into the bottom and sides, may be used for holding or shipping the specimens. The box should not contain so much cotton that the specimens will come in contact with the lid, and if more than a wisp is used, its weight will cause it to shift about in the box during shipment. Cotton should not be placed on top of the specimens. Specimens that have been moistened, crushed, or rubbed are usually unsatisfactory for identification.

The suction type of light trap, as developed by New Jersey workers (fig. 6), is being used extensively for obtaining samples of the mosquito fauna of an area, and records of the relative abundance of different species, particularly in connection with control operations. The specimens are more or less damaged during capture, however, and are usually unsuitable for the permanent collection. The original model of this trap and an improved design have been described by Mulhern (*231*). Light-trap collections in comparison with collections by other methods are discussed under Mosquito Surveys in the section on Mosquito Control.

Adult specimens that are to be retained in the permanent collection should be mounted and pinned into a Schmitt box or similar tight insect box having a bottom lining of sheet cork or balsa wood. Freshly killed specimens may be mounted on



M & A 14048 A

FIGURE 7.—Types of mounts used for adult mosquitoes.

minuten pins, and dry specimens on points cut from stiff paper (fig. 7). In using the paper mount, an entomological pin is passed through the base of the narrow paper triangle and a small drop of cement is dabbed on the tip of the paper. The paper is then pressed gently onto the side of the thorax of the mosquito, with the tip directed toward the mesonotum. Care should be taken not to smear the legs or wings with the cement. For uniformity, the points are usually stuck onto the left side of the specimen. A cellulose cement is preferable to the shellac formerly employed; it may be purchased at hardware stores in small tubes or it may be prepared by dissolving celluloid in amyl acetate (known also as pear oil or banana oil). Ambroid thinned with amyl acetate is one of the cements used. Because of the volatility of the amyl acetate the stock of cement must be thinned frequently. In making the minuten-pin mount, the small pin is stuck into a small square or rectangular piece of cork, through which is also passed a larger pin (fig. 7). The tip of the small pin is then thrust through the thorax of the mosquito, usually from between the coxae toward the back. The tip of the pin should not protrude through the mesonotum. Very small, dry specimens may be stuck on the side of the minuten-pin point with a drop of cement, instead of using the paper point. The No. 3 entomological pin is probably the best size to use with both types of mounts.

Care must be taken to protect the stored specimens from insect pests, and for this purpose flake naphthalene or paradichlorobenzene are most frequently used. The material may be sprinkled in the box or placed in a perforated container fastened in one corner of the box. Specimens that are to be kept temporarily in pill boxes may be protected by sprinkling a little flake naphtha-

lene on the bottom of the box and covering this with a thin layer of cotton before introducing the mosquitoes. For longer storage the pill boxes may be kept in a larger box containing naphthalene or paradichlorobenzene, which must be renewed occasionally.

MOSQUITOES AND DISEASE

Mosquitoes rank as the most important insect pests of man. They scourge him with their vicious biting attacks, which alone have made sections of the globe almost uninhabitable, but of more importance they transmit to him some of his most distressing diseases. Chief of these are malaria, yellow fever, dengue, filariasis, and the arthropod-borne encephalitides. In addition, mosquitoes are known to transmit heartworm of dogs, bird malaria, and fowl pox. Also, they transport to man the eggs of a South American fly, *Dermatobia,* whose larvae upon hatching cause myiasis, and they may be vectors of tularemia and leishmaniasis.

Malaria is caused by tiny protozoan parasites of the genus *Plasmodium,* which invade the red-blood corpuscles. There are four species of human malaria parasites, three of which—*Plasmodium vivax, P. malariae, P. falciparum*—are distributed generally in temperate and tropical regions, while the fourth, *P. ovale,* is rare and of restricted occurrence. *P. vivax* is the most common form in North America. It causes *vivax* or tertian malaria, so called because the paroxysms or "chills and fever" which are characteristic of the disease occur every third day (48 hours). In *falciparum,* malignant or sub-tertian malaria, the paroxysms occur every 40 to 48 hours, while with *P. malariae* or quartan infections the paroxysms come every 72 hours.

Both man and the mosquito are essential to the propagation of malaria. In man, the parasite lives and multiples in the red-blood corpuscles. This is the asexual cycle, which usually is completed in from 48 to 72 hours depending on the parasite species, following which immense numbers of blood cells disintegrate and discharge the parasites and their wastes into the bloodstream to cause the characteristic paroxysms of the disease. Meanwhile, part of the parasites develop into sexual forms, or gametocytes. The anopheline mosquito here becomes essential, for further development depends on these gametocytes reaching the stomach of the mosquito where the sexual cycle takes place. This requires from 10 to 20 days or more, and results in tremendous multiplication of the parasites which, as sporozoites, penetrate all parts of the mosquito body. Eventually these concentrate in the salivary glands from which the mosquito ejects them along with saliva while biting its next host. An infected mosquito may transmit the disease to several human victims before its store of sporozoites is exhausted. All of the anopheline mosquitoes of the United States except *georgianus* and *perplexens* have been found susceptible to infection by malaria parasites. However, epidemiologic evidence indicates that *Anopheles quadrimaculatus* in the Southern and Eastern States and *A. freeborni* Aitken in the West are the principal transmitters, and control measures therefore have been aimed specifically against these two species with effective results. *Anopheles albimanus,* an important malaria vector

in the American tropics, occurs sparingly in south Texas and on the Florida Keys but is not known to be of importance in these areas.

Opinions differ as to whether malaria existed in North America prior to the coming of the white man; it is known that the disease became a problem early in the history of the United States and it may have been brought here originally by the colonists or by slaves from Africa. By the middle of the 19th Century malaria was occurring widely throughout the country. Since then it has undergone cycles of increasing and decreasing occurrence, the latter predominating, with the net result that by 1930 it was restricted as a disease of importance to the Southeastern States where it appeared to be firmly entrenched. However, a very rapid decline in incidence began in the mid 1930's, which carried through the war years. Subsequently, using principally DDT against the anopheline vectors, State and Federal health agencies have cooperated in waging an eradication campaign. As a result, except for minor self-limiting episodes, malaria transmission has almost ceased in this country. Total cases reported to the Public Health Service numbered only 707 and 477, respectively, for 1954 and 1955, and of these only 8 and 4 cases, respectively, were confirmed as primarily indigenous in origin. In 1956, the number of reported cases fell to 234, but the number of indigenous cases has not been reported.

Malaria also occurs among birds in the United States, and seven avian species of *Plasmodium*, all different from the human malaria parasites, are known to occur here. These malarias may be transmitted by various mosquitoes of the genera *Culex*, *Aedes*, and *Anopheles*. Bird malaria infections are not known to be of particular importance in this country where they affect principally the passerine birds. In Ceylon and Borneo, however, other species of *Plasmodium* occur, which cause high mortality in chickens and ducks. Studies of avian malaria parasites have led to clarification of many obscure phenomena in the biology of human malaria. Also, the screening of anti-malaria drugs has been greatly expedited by the use of birds parasitized with various species of *Plasmodium*.

Yellow Fever is an acute febrile virus disease which is endemic principally among monkeys and other primates in the jungles of the American Tropics and in Africa. Here, various species of jungle mosquitoes belonging to the genera *Haemogogus*, *Aedes*, *Culex*, *Eretmapodites*, *Mansonia*, *Psorophora*, *Sabethes*, *Wyeomyia*, and *Limatus* are known to be capable of transmitting the virus. At present, *Haemogogus spegazzinii* Brethes is believed to be the principal vector in the forests of South and Central America. On occasion the disease is carried to urban communities, and if the domestic mosquito *Aedes aegypti* is abundant in such communities, the disease may spread rapidly. During the 18th and 19th centuries many epidemics occurred in Gulf and South Atlantic coastal cities in the United States, and at times the disease spread to inland cities as well. Epidemics occurred occasionally in Atlantic ports as far north as Boston, being started there by infected *A. aegypti* coming ashore from ships which had arrived from infected ports farther south.

In 1900, Dr. Walter Reed and his associates confirmed the observations and experiments of Dr. Carlos Finlay, a Cuban physician, which pointed to *A. aegypti* as the vector of yellow fever, thus establishing that control of this mosquito was the clue to controlling the disease.

The last epidemic of yellow fever in this country occurred in 1905, at which time the efficacy of anti-*aegypti* measures in controlling the disease was convincingly demonstrated, as it already had been in countries to the south of us. Because yellow fever continued to occur sporadically in some cities in the Tropics even when *A. aegypti* populations were maintained at low levels by control programs, and because of the relative ease with which the species could be entirely eradicated from a community, the Pan American Sanitary Organization, in 1947, decided that eradication of *aegypti* from the southern continent was the only logical goal to set in dealing with the problem. To date, several countries are reported to have achieved such eradication and thus have eliminated the possibility of urban yellow fever epidemics. Nevertheless, jungle yellow fever is a continuing problem for which no feasible eradicative measures are known. The vaccination of all persons likely to become exposed is the only solution at present.

In the United States, federal quarantine officers at ports of entry constantly are on guard to prevent *A. aegypti* from being inadvertently brought into the United States, since such specimens may have become infected with yellow fever in their country of origin. Officers also keep airport and dock areas under surveillance so that any vector breeding can be eliminated promptly, thus preventing infestation of ships or planes leaving this country. Some port cities carry on mosquito-control programs, which greatly facilitates this work, and may result eventually in the eradication of *aegypti* from these localities. Such eradication already has been reported for Key West, Fla.

Dengue, or "breakbone" fever, is a nonfatal, acute, febrile, virus disease that is endemic in tropical and sub-tropical areas of the world. The disease is characterized by the sudden onset of high fever, severe headache, backache, and excruciating pains in the joints—to which the common name "breakbone" refers. *Aedes aegypti* is the principal vector of dengue fever, although it also is transmitted by other members of the subgenus *Stegomyia* such as *Aedes albopictus* (Skuse) in the Philippines and Hawaii and *A. scutellaris* (Wlk.) in New Guinea. Mosquitoes become infected by feeding on persons having the disease, during a 4- or 5-day period beginning with the day preceeding the onset of symptoms. Then follows a period of 8 to 14 days during which the virus multiplies in the mosquito, after which the mosquito may remain infective for life. Like yellow fever, dengue is a disease of monkeys, and these animals serve as reservoirs between epidemic periods.

Dengue may also occur in epidemic form. In the United States, where *A. aegypti* is the vector, an epidemic in 1922 in the South affected some two million persons, of which number 600,000 to 1,000,000 were in Texas. In 1934 a less severe outbreak occurred in Florida and spread northward into Georgia.

The most important of the arthropod-borne viral encephalitides occurring in the United States are eastern equine encephalitis (EEE), western equine encephalitis (WEE), and St. Louis encephalitis (SLE), all of which appear to be transmitted principally by mosquitoes. Similar viruses, such as Venezuelan and Japanese B, are known in other parts of the world. Encephalitis results from infections with specific neurotropic viruses which cause inflamation of the central nervous system. The disease may be very mild, moderately severe, or have an abrupt onset with high fever and coma. The human fatality rate ranges from 5 to 60 percent, while the equine fatality rate may range up to 90 percent, the highest rates occurring in eastern equine infections. Both the eastern and western viruses occur in the Southeastern States, the former the more frequently (*21*). Although epidemics among mules and horses have occurred, there have been few human cases in this area. No outbreaks of St. Louis encephalitis have been recorded but outbreaks have occurred in the bordering States of Kentucky and Texas. In addition, to man and equines, these diseases affect a variety of other animals. Wild and domestic birds frequently have been found with inapparent infections and undoubtedly are important reservoirs. Present knowledge indicates a bird-mosquito-bird cycle of transmission for these diseases, with equines and man only accidental hosts, playing no essential role in the transmission chain.

Kelser (*180*) was the first to report experimental transmission of encephalitis (WEE) with a species of mosquito (*Aedes aegypti*). Since that time, numerous other mosquitoes have been shown to be capable of transmitting the viruses of encephalitis experimentally, and a number of species have been found to harbor infections acquired under natural conditions. In the Western States, *Culex tarsalis* is believed to be the principal vector because of the frequent occurrence of such infections. From records compiled by Ferguson (*109*), 144 isolations of WEE and 14 of SLE had been made prior to 1951 from wild-caught specimens of this species. Natural infections with the different viruses also have been found in pooled lots of other mosquitoes that occur in the Southeastern States. Some of the isolations were made from mosquitoes collected in the Southeast and some from mosquitoes collected in other parts of the country. The species and the types of virus recorded are: *Aedes dorsalis*—WEE (*139, 304*), SLE (*136*); *Aedes infirmatus*—WEE (*196*); *A. mitchellae*—EEE (*176*); *Anopheles crucians*—EEE (*176, 196*); *Culex pipiens pipiens*—WEE and SLE (*138*); *C. restuans*—WEE (*240*); *Culiseta inornata*—WEE (*138*); *C. melanura*—EEE (*71*); *Mansonia perturbans*—EEE (*164*). A new strain of virus called California encephalitis was isolated first in 1943 from specimens of *A. dorsalis*, and subsequently from both *A. dorsalis* and *C. tarsalis* (*136, 137*).

In quantitative studies of the virus-vector relationship by Chamberlain *et al.* (*72*), the vector potentials of 23 species of mosquitoes with WEE and EEE viruses were determined and were rated as excellent, good, fair, and poor. For the Southeastern species the ratings were as follows: "Excellent" or "Good"—*Aedes aegypti* (WEE, EEE), *A. atropalpus* (WEE,

EEE), *A. sollicitans* (WEE, EEE), *A. triseriatus* (WEE, EEE), *Culex restuans* (EEE), *Mansonia perturbans* (EEE), *Orthopodomyia signifera* (WEE, EEE), *Psorophora confinnis* (WEE, EEE), *P. ciliata* (WEE), *P. discolor* (WEE), *P. ferox* (WEE); "Fair"—*Aedes vexans* (WEE, EEE), *Culex erraticus* (EEE), *Psorophora ciliata* (EEE), *P. ferox* (EEE); "Poor"—*Anopheles crucians* (EEE), *A. quadrimaculatus* (WEE, EEE), *Culex p. quinquefasciatus* (WEE, EEE), *C. salinarius* (WEE, EEE), *Mansonia indubitans* (WEE), *Psorophora discolor* (EEE), and *P. howardii* (EEE).

Experimental transmission of encephalitis virus by several of the above species has been reported by other workers. Additional Southeastern species that have shown ability to transmit infection include *Aedes taeniorhynchus* (WEE, EEE, SLE) and *A. sticticus* (SLE). Also the St. Louis virus has been transmitted experimentally by *Aedes aegypti, A. vexans, Culex p. pipiens, C. p. quinquefasciatus, C. tarsalis,* and *Culiseta inornata.* These records and a bibliography up to 1951 may be found in the valuable compilation by Ferguson (*109*).

Human filariasis is a disease of widespread occurrence in the tropical and subtropical regions of the world. It formerly was endemic in the Charleston, S. C., area but no cases have been known there in recent years, and it appears to have been eradicated. Filariasis is caused by infections with nematode worms of two species, *Wuchereria bancrofti* and *W. malayi.* The adult worms live in various parts of the lymphatic system of man. The young of these worms, or microfilaria, are discharged into the blood stream where they are picked up by mosquitoes while biting. About 10 days are required for development in the mosquito, after which they migrate to the mouth parts, from which they reach a new host when next the mosquito feeds. They are not injected into the host directly but break from the labium of the mosquito onto the skin and enter the body through the biting puncture or other skin abrasion. Prolonged or repeated infections in man may result in enormous enlargements of the external genitalia, mammary glands, and limbs, often called elephantiasis. Many mosquitoes of the genera *Aedes, Culex, Mansonia,* and *Anopheles* are known to be capable of acting as intermediate hosts of the parasites in various parts of the world.

During World War II large U. S. forces served in areas in the Pacific where filariasis was endemic, and some infections occurred. The majority of these cases became completely inactive within 2 years after leaving the endemic area, and the very low incidence made it unlikely that American mosquitoes would become infected by returning servicemen (*106*). Nevertheless, this possibility was given careful consideration, and the ability of several species of U. S. mosquitoes to act as vectors was determined.

Newton, Wright, and Pratt (*236*) and Newton and Pratt (*235*) concluded from a series of studies that under conditions favoring transmission *Culex p. pipiens, C. p. quinquefasciatus, C. tarsalis* (and possibly *C. erraticus*), *Psorophora discolor, P. confinnis,* and *Anopheles albimanus* would be potential vectors; that the infectability rates of *Culex salinarius, C. nigripalpus, Aedes aegypti,*

A. triseriatus, A. thibaulti, and *Anopheles crucians* were too low to consider them as likely to play an important role in transmission; and that *Aedes sollicitans, A. taeniorhynchus, A. vexans, A. canadensis, Anopheles punctipennis, A. quadrimaculatus, Psorophora ciliata, P. cyanescens,* and *Mansonia perturbans* appeared to be incapable of transmitting *Wuchereria bancrofti* infections.

Eyles and Most (*106*) observed the development of *W. bancrofti* to advanced or infective stages in *Culex p. pipiens, C. p. quinquefasciatus, C. erraticus, C. salinarius, Anopheles punctipennis, A. walkeri, Aedes triseriatus, A. aegypti, A. atropalpus* and *Mansonia perturbans.* They considered however that only the first two of these species, which had infectivity rates of 83.5 percent and 34.9 percent, respectively, were sufficiently susceptible to be dangerous potential vectors. They reported that infections failed to develop significantly in *Anopheles quadrimaculatus, Aedes atlanticus* (or *tormentor*), and *Psorophora ferox.*

Another filarial worm, *Dirofilaria immitis,* causes heartworm disease of dogs, an infection that is widespread in warm climates and occurs commonly in the Southeastern States, where it causes serious losses, particularly in coastal areas. The adult worms are usually found in the right ventricle of the heart and the adjacent pulmonary artery. The microfilaria are discharged into the blood stream as with *Wuchereria* species. Transmission may be by various species of mosquitoes of the genera *Aedes, Culex,* and *Anopheles.* Hu (*165*) lists the following Southeastern species which may serve as intermediate hosts: *Anopheles punctipennis, Aedes aegypti, A. canadensis, A. sollicitans, A. taeniorhynchus, A. vexans, Culex p. pipiens, C. fatigans* (*p. quinquefasciatus*), *C. restuans,* and probably *C. salinarius.* Yen (*336*) reported that large numbers of larvae completed development in *Anopheles maculipennis* Meig. and *A. punctipennis,* but that only a part of the larvae reached the infective stage in *Culex territans* (probably *restuans*), *C. tarsalis, C. p. pipiens, Aedes cinereus, A. vexans, A. canadensis, A. stimulans,* and others. None developed in *Culiseta inornata, Mansonia perturbans,* and *Aedes trivittatus.* Kartman (*177*) gave the following percentages of infections in specimens fed at the same time on an infected dog: *A. quadrimaculatus*—99.5, *C. p. pipiens*—29.8, *C. p. quinquefasciatus*—39.9, *A. aegypti*—34.5.

Fowl pox is a common and widespread virus disease of poultry, which normally is transmitted by contact. It may be spread also by a number of species of mosquitoes including *Culex p. pipiens, Aedes aegypti,* and *A. vexans,* which occur in the Southeastern States (*200, 216*).

MOSQUITO CONTROL

Mosquito control may be undertaken either as a means of preventing mosquito-borne diseases or to protect man and animals from their vicious attacks. Throughout the world the principal antimosquito activities have been directed toward disease prevention. Within the United States, however, many of the largest operations have been undertaken for the sole purpose of preventing annoyance, for mosquitoes are not only a detriment to

human welfare and happiness but their attacks result in direct economic losses through reduced property values, injury to livestock, and reduced efficiency of labor. These losses frequently are much greater than the cost of mosquito control.

Nearly everyone is familiar with the efforts made to eliminate mosquito-breeding places, and with the use of insecticides in antimosquito work. The practical phases of the problem, however, form a large specialized subject, and a general summary only will be given here with reference to underlying principles and to the practices and materials that have become more or less standardized, or are of recent development.

MOSQUITO SURVEYS

Mosquitoes have extremely diverse breeding habits, particularly in respect to the type of place selected for oviposition. Because of this diversity, the species to be dealt with and their individual habits must be known before control measures can be applied intelligently.

If the work is undertaken for the control of a disease such as malaria or dengue fever, the presence of the disease itself, in the Southern States at least, indicates the particular species responsible, because the vectors of these diseases are well known. A study of the distribution of human cases serves to localize the problem, and a mosquito survey is undertaken to aid in developing a plan of procedure. At the same time, the possibility of including control measures against purely obnoxious species should not be overlooked. Where relief from annoyance is the main object, a thorough survey is necessary to determine the relative importance of the different species, since more than one is usually involved. Even in coastal areas, where it is known that the salt-marsh species are the principal culprits, it is still highly important to know whether fresh-water breeders are sufficiently numerous to require consideration.

The surveys are begun by the collection and identification of both adult and larval specimens. During an outbreak of mosquitoes the species involved can be determined quickly by collecting adults from various parts of the affected area. In localities where mosquitoes are present more or less continuously, or where outbreaks are of frequent recurrence, collecting should be repeated often enough to determine the relative annual abundance of the different species. At the same time information should be accumulated as to the breeding places of the common species, the topography of the area, and the extent of the control problem. A year should ordinarily be regarded as the minimum time for such preliminary studies, since mosquito abundance varies greatly with the seasons. Several years are required to obtain reliable averages as to normal abundance. Although adult control operations and the treatment of obvious breeding places usually can be begun before such an extensive survey is completed, the practice of beginning major operations with inadequate information is highly wasteful, and may result in complete loss of public confidence in a worthwhile project, possibly causing its abandonment. An important item in the annual budget for financing the control operations should be provision for continuing the systematic

collection and identification of specimens. Such work will furnish invaluable information as to seasonal changes in the mosquito problem and outbreaks from overlooked or distant breeding areas, and is indispensable in measuring the results accomplished.

General methods of collecting mosquitoes have been discussed in a preceding section. Some of the special methods employed for obtaining data necessary in connection with surveys and control operations are described in the following paragraphs.

Biting Records and Landing Counts

Collecting mosquitoes while they are biting is the simplest and most direct method of determining the relative abundance of the different bloodsucking species. Such collections are usually made with a chloroform tube or other type of killing bottle. For data on comparative abundance in different parts of the area or at different times of the year, stations are selected, and collections made for equal periods and under conditions as nearly uniform as possible. In obtaining such records the writers have adopted the procedure of sitting on a box or stool at the selected place, with the trouser legs rolled to the knees. After a minute or so has been allowed for the mosquitoes to accumulate, they are collected as they alight for a period of 10 or 15 minutes (*192*). If the collecting is done after dark, a flashlight is necessary. Two 15-minute collecting periods or three 10-minute periods may be totaled and multiplied by 2 for the hourly rate. Collections made during the first flight period (just at dark) should not be averaged with later collections as the numbers are usually much larger at that time.

When the mosquitoes are numerous, the numbers caught can be increased considerably by placing a short paper funnel, or guard, in the mouth of the collecting tube (fig. 5), since this permits the collector to move to the next specimen without waiting for the first one to succumb to the chloroform fumes. The guards are useful otherwise in conserving the strength of the chloroform and in preventing the loss of specimens when the mouth of the tube is turned downward. An aspirator is also used for such collections.

When collecting after dark the writers have taken an average of 10 mosquitoes per minute, or 600 per hour, with a chloroform tube. If the mosquitoes are much more numerous than this, the discomfort of collecting is so great that it is considered sufficient to record abundance as 600+, or other observed rate, per hour. When the collecting is to be done at different places by two or more persons, preliminary collections should be made at one place to determine the relative attractiveness, and also the dexterity of the different collectors, as much variation has been found in these respects.

For those species that attack during the day, such as the salt-marsh mosquitoes, landing counts give rapid comparative records of the numbers present, and such counts are useful especially in obtaining data before and after insecticidal treatments to provide estimates of the reduction. These are conveniently made by pausing for half a minute at the site to be sampled and

then counting the number alighting on the front of the trousers during one minute. The counts are sometimes made by two men, one counting the mosquitoes alighting on the back of the other (pl. 1, *A*). The records are obtained at a number of points to give an average count for each plot or area.

Hand Collections or Counts of Resting Mosquitoes

Some species can be obtained by daytime collecting in dark corners and other places where the adults (including the males) spend the daylight hours. This is an excellent method of obtaining comparative data on densities of adult *Anopheles,* especially those species found in the United States, since they fly into a shelter at daybreak and remain quiet throughout the day. This method is safer than the biting method if disease-bearing mosquitoes are present.

Favorable daytime resting places for *Anopheles* are underneath buildings that are raised 2 or 3 feet from the ground, and inside tightly boarded outbuildings or similar locations. In making the surveys, a series of stations well distributed over the area under observation are selected, and weekly, biweekly, or monthly collections are made (*162, 183*). At each location the most favorable resting place is selected after examination of all the buildings on the premises. When the surveys are purely for comparative purposes, the collecting station does not always need to be an entire building if it is found that one part is more favorable than another or that parts of the building are not conveniently accessible. Where the resting surface is fairly smooth and unobstructed, a well-trained and reliable collector, with the aid of a flashlight, can obtain satisfactory counts of the resting mosquitoes in much less time than would be required for collecting the specimens in killing bottles or aspirator tubes. The sex can be determined and in most cases the species identified on sight. Collections over a definite period (10 or 15 minutes) have been used as an index of density, but they may be unreliable because of variations in the rate of collection under different conditions as well as in the mechanical limitations to the numbers of mosquitoes that can be collected in a given time. Artificial resting places may be constructed in favorable sites from horizontally placed barrels or boxes mounted on posts. A privy-type building with a lower panel removed on the west side for entrance of the mosquitoes was found to be much more efficient than nail kegs (*64, 293*). Various traps for use in anopheline surveys have been discussed by Bradley *et al.* (*48*).

Trap Collections

For most species the suction type of light trap (fig. 6) is very useful for obtaining samples of the mosquito population, for records of comparative abundance and, in control areas, for immediate information on the occurrence of outbreaks. In control work the traps are placed at strategic places throughout the area and are usually operated every night. For other purposes, the traps may be run on a schedule of one or more nights each week. The traps should be hung in an open space with the light itself

5 or 6 feet from the ground, and they should not be placed in the immediate vicinity of a strong light if this can be avoided.

The number of mosquitoes caught per night frequently runs into the hundreds or even thousands, and many other kinds of insects are found in the killing bottles. These conditions make the task of separating and identifying the material a considerable one, especially when the specimens are badly damaged or wet; simplified procedures for this work have been described by Bradley and Travis (*51*). Species not taken while biting appear in the light-trap collections, and it has been found that the different bloodsucking species are not attracted to the light equally. Over a series of nights the writers' trap-collection records have shown more variation than the biting records, which, of course, are the more accurate index of annoyance. From a large series of trap collections made in Florida only an occasional specimen of *Aedes aegypti* has been obtained, and the numbers of *Culex pipiens quinquefasciatus* and *C. nigripalpus* appear to be very small in comparison with the amount of breeding in the neighborhood of the traps. This also seems to be true to some extent of *Anopheles quadrimaculatus*. The trap records, therefore, cannot be relied on to provide exact indices of density for these species. Comparative data for several methods of collecting have been given by Huffaker and Back (*167*) and Provost (*258*).

Carbon dioxide attracts mosquitoes, and light-trap catches may be increased by placing a piece of dry ice on or beside the trap, (*143, 144, 167*). The traps also may be operated without lights, but with the fan running, to sample the mosquitoes active at a given site without an attrahent. A portable light trap that is operated from an automobile battery has been described by Seaman (*285*), and a light trap powered by dry-cell batteries has been described by Nelson and Chamberlain (*234*). A rotating trap powered by an electric or gasoline motor has been designed by Chamberlin and Lawson (*74*). Rigid screen-wire funnels are mounted at the ends of two or four arms, which extend at right angles from the upright rotating central shaft. The device is adjustable so the funnels may be operated at selected elevations above the ground. The small end of the funnel is open and a small cloth bag is attached to hold the insects that are swept in.

A truck trap, consisting of a large screen funnel with a front opening 2 × 8 feet mounted on the top of the cab of a pick-up truck, was employed by Provost (*258*) to sample the mosquito population on the wing after dark. The truck was driven for set distances at a speed sufficient to intercept the flying insects. Smaller funnels mounted on the front fenders of automobiles have also been employed.

Animal-baited traps have been used for collecting mosquitoes and, in the Tropics at least, have been employed for determining densities of anopheline species that do not remain in accessible shelters during the daytime. A number of such traps have been described (*see* Bradley *et al.* (*48*)).

Collections of Larvae

Collections of larvae are made primarily to locate the breeding

places and determine their importance. Information as to the comparative abundance of different species may be obtained from the identification of a large series of collections. Rough estimates of the relative abundance of a species can be obtained by counting the larvae per dip in a series of dips. The relative importance of the area in mosquito production can be expressed numerically by multiplying the average number per dip by a factor representing the extent of the breeding area (size times percentage of breeding surface). The productivity of a breeding place per unit of surface can also be determined by the use of cloth nets or screen cages placed over the water (*43*).

Breeding places may be divided into two general classes—permanent and temporary. The two classes frequently intergrade, however, and the status of a given area may change over a period of time. *Anopheles* and *Culex* occur typically in the permanent breeding places, whereas most *Aedes* and *Psorophora* are found in the temporary collections of water produced by rainfall, floodwaters, or high tides. The status of the breeding places, particularly the permanent ones, as to productivity may change greatly during the course of a season or from year to year, owing to changes in the amount of aquatic growth or flotage, the abundance of natural enemies, and other causes.

The importance of temporary breeding places of *Aedes* and *Psorophora* is frequently difficult to determine, because considerable time may elapse between broods. One may visit suspected low areas repeatedly without finding larvae, but such areas must be classified as potential breeding places, until repeated floodings with negative results have been observed. The type of vegetation, especially in salt marshes, is often an indicator of the suitability of breeding conditions. Breeding occurs on the parts of the marsh that are above the normal daily tidal range, and the elevations are indicated by the type of plant growth, since many of the plant species are restricted rather sharply by the height of the water table and the frequency of tidal coverage. More definite information on suspected breeding areas can sometimes be obtained from samples of sod taken from dry depressions, or in vegetated areas by scooping off a thin layer of topsoil with a small shovel. Samples from different parts of the area are placed in containers and covered with water to cause hatching of the eggs, which may begin within a few minutes. Glass containers are preferable, as the small larvae are more easily seen when these containers are held against the light. If the sods are very moist at the time of collection, drying in the air for a week or so may be necessary to induce hatching of the eggs.

ENGINEERING SURVEYS

During a mosquito survey much information will be accumulated which will be valuable in determining the feasibility of an anti-mosquito project, and the best method to be employed in handling specific problems. Where malaria or salt-marsh mosquitoes are to be controlled, an engineering survey should next be undertaken to lay out a detailed plan of procedure, and to determine the approximate cost. Whether the local situation can

be handled successfully within the means at hand, or at a cost commensurate with the probable benefits, is one of the first questions to be decided. The legality of the proposed work (including jurisdiction over the area involved), the probability of obtaining necessary easement on private property, et cetera, must also be considered. A summary of State mosquito-control legislation has been compiled by Keefe and Beadle (*178*).

Good maps are, of course, essential, and should be available both in small scale for use as key maps and in large scale for showing in detail the breeding places, ditching lay-outs, and natural topographic features. The different areas and the individual breeding places can then be given names or numbers for convenient reference to the mosquito-collection and engineering notes. Aerial photographic maps of rural or marsh areas are extremely valuable, as they show the bodies of water and the types of vegetation. A note-card system should be arranged, and complete records kept of all inspection and survey data.

For breeding-place or other preliminary surveys when elevations or exact locations are not required, the directions given by Hulse (*168*) for preparing field maps in public-health work, based on methods employed in the military service, are very useful.

CONTROL OF MOSQUITO LARVAE

Mosquito-control measures are usually directed against the larvae in areas where the breeding places may be eliminated by filling, ditching, impounding, or other water-manipulation procedures, or where the chemical treatment of relatively restricted breeding grounds will eliminate mosquito annoyance over an extensive inhabited area. Anti-larval measures may not be economical where the breeding area is extensive and the nuisance area small, particularly if the necessary measures will interfere with important conservation programs.

Elimination of Breeding Places

Where at all feasible, efforts should be made to eliminate the breeding places permanently by filling, drainage, or sanitation. Under some conditions breeding may be reduced or eliminated by controlling the water level with impoundments.

Filling is frequently a practical method and gives permanent relief when the fills are so placed or graded as to leave no water-holding depressions. Large hydraulic fills may show shrinkage or surface cracks upon drying and require one or more regradings to prevent mosquito breeding.

Drainage undoubtedly has the widest application of the various anti-larval measures, especially in the control of the malaria carriers and the salt-marsh species. The drainage of swamplands in the United States has done much to reduce the malarious area and at the same time has made the land suitable for agriculture. Drainage or ditching purely for mosquito control, however, should be looked upon as distinct from agricultural drainage, since it is directed mainly toward the elimination of surface water during the time required for larval development, or to aid

in biological control. Comprehensive drainage plans should be prepared with the aid of trained engineers.

Two phases of the drainage problem in mosquito control to which attention should be called are its possible effects upon wildlife, and its possible effect upon soil conservation. Through cooperative biological studies efforts have been made to determine what measures may be applied to large swamp areas, particularly those not close to centers of population, which would disturb as little as possible the natural breeding and feeding grounds of aquatic wild fowl and other desirable animal life without sacrificing the success of the mosquito-control project. Specialists in soil conservation have called attention to the adverse effects of the drainage of natural upland storage basins, the cleaning of stream channels, and the "brushing" of stream banks, all of which increase the rapidity of run-off of flood-water with consequent erosion that may cause serious damage to agricultural lands. Such erosion is said to cause frequently a gradual widening of the flood plain and silting-up of downstream areas which may create mosquito-producing areas as serious as those remedied.

Such factors as these must be considered in planning mosquito-control programs, and they emphasize the need of obtaining advice from competent specialists when making the preliminary surveys. The impoundage of water rather than drainage may be employed successfully in many cases, both in salt-water and fresh-water areas, since an open pond with clean margins and containing mosquito-destroying fish is not favorable for mosquito breeding (*312*, pl. 2). Where the sacrifice of wildlife habitats appears necessary to accomplish effective mosquito control, a decision must be made as to the greater benefit to be derived.

Sanitation, as applied to mosquito control, includes such measures as the elimination of artificial and other breeding places. It also involves the treatment of permanent bodies of water and removal of aquatic vegetation and other protective harborage to make them unfavorable for mosquito development.

Larvicides

Various larvicides are employed where permanent methods of control are not feasible, or as temporary expedients until permanent measures can be installed. Prior to World War II the most widely used larvicides were oils, paris green, and pyrethrum. Investigations begun in 1943 at the Orlando laboratory demonstrated the remarkable effectiveness of DDT which, unlike the larvicides previously used, gave unprecedented control at dosages as low as 2 to 4 quarts of spray per acre, thus permitting the treatment of large areas from the air at reasonable cost. Originally DDT was used only in connection with military operations, but after the war it became generally available and was adopted by many civilian mosquito-control agencies. Within a short time several other chlorinated hydrocarbons also were shown to be effective larvicides.

The extensive use of DDT for several years in some localities resulted in the development of resistance in some species, notably salt-marsh mosquitoes in Florida and *Culex tarsalis* in California, whereas other species, such as *Anopheles quadrimaculatus* in the

Tennessee Valley, have remained susceptible to DDT in a continuing control program. Resistance in restricted areas in Maryland and Georgia was reported in 1959. The species that became resistant to DDT quickly acquired resistance to other chlorinated hydrocarbon larvicides, but as yet they continue to be susceptible to several of the newer insecticides, particularly to the organophosphorus compounds including parathion, EPN, malathion, Dipterex, and Co-Ral. Increased resistance to malathion has been reported in *Culex tarsalis* (*126*), and it should not be assumed that resistance to the organophosphorus larvicides will not eventually be developed by other species.

The investigations leading to the recommendation of DDT as an anopheline and culicine larvicide have been described by Deonier *et al.* (*85, 87*), Eide *et al.* (*103*), and Knipling (*204*). Many agencies have contributed to the development of practical application methods. Detailed instructions as to the dosages, formulations, and equipment used to apply DDT and other larvicides in various situations will be found in U. S. Department of Agriculture Circular 977 (*310*), American Mosquito Control Association Bulletins 1 and 2 (*2, 3*), and the Operational Memoranda issued annually by the Communicable Disease Center, United States Public Health Service.

Technical DDT in an oil spray or in an aqueous emulsion of an oil solution is the most widely used mosquito larvicide. In an oil spray it is usually dissolved in kerosene or fuel oil in concentrations ranging from 5 to 1 percent or less, depending on the type of dispersal equipment to be used. Concentrated solutions are sometimes made in other solvents to be diluted with oil as needed. The remarkable larvicidal action of DDT permits great savings in materials and labor. Whereas 10 to 25 gallons of oil without DDT is applied per acre to control culicine larvae, control can be obtained with 5 quarts of a 1-percent DDT solution or 1 quart of a 5-percent solution when properly dispersed. To effect the greatest savings the volume of solution applied should be the lowest that will provide complete coverage with the equipment at hand, and the concentration should be adjusted to give a dosage of about 0.1 to 0.2 pound of DDT per acre. Under some conditions higher dosages may be required, as in heavily polluted waters for the control of certain species of *Culex*, where about 0.4 pound per acre is needed.

DDT emulsions are commonly prepared from concentrates containing 25 to 35 percent of the insecticide. These are diluted for use and are applied at the same concentrations and dosage rates as the oil solutions. They are highly effective as larvicides, and have obvious advantages over oil solutions in transportation, but are more injurious to fish and other beneficial aquatic life.

DDT suspensions, prepared from wettable powders containing 50 to 75 percent of the insecticide, are less effective than oil solutions or emulsions as larvicides and, if their use is dictated by other considerations, they should be applied at heavier dosages.

DDT dusts are highly effective against anopheline larvae, and are particularly useful where long-distance drifting is needed to treat wide breeding areas, but in many situations the drift causes excessive loss. Dusts penetrate thick vegetation, if it is dry, better

than liquids. Against culicine mosquitoes, dusts are usually less effective than solutions or emulsions, but rather heavy applications to cisterns, tanks, dumps, and rubble-filled areas have been effective in the control of various species of *Aedes* and *Culex* during military operations.

Granules or pellets containing 1 or 2 percent of the insecticide and applied at about 5 or 10 pounds of granules per acre provide effective larvicidal action together with good penetration of vegetative cover and elimination of loss by drifting. They have been especially effective in Florida mangrove marshes when dispersed from the air, although various insecticides other than DDT have usually been employed because of DDT resistance. Several sizes of granules are equally effective biologically; those passing through screens having 16/30 meshes per inch are a convenient size, and are large enough to prevent drifting, yet small enough to provide about 200 granules per square foot when distributed at 10 pounds per acre.

Aircraft frequently are used for the dispersal of solutions, emulsions, dusts, and granules, but are rarely equipped to disperse suspensions of wettable powders, which require continuous agitation. A 5-percent solution of DDT in oil has been used most commonly with small planes. The output is usually adjusted to give a dosage of 2 quarts (about 0.2 pound of DDT) per acre at normal flying speed, although either the concentration or volume may be varied to give any desired dosage. With larger and faster planes, 20-percent solutions have been applied at 1 pint per acre for effective control. Emulsions are usually delivered from small planes under conditions that permit low-altitude flying to reduce the evaporation of the water. Aerial dusting is now seldom employed in mosquito control, except where planes equipped for crop dusting are the only ones available, since the dusts are less effective than sprays against culicines. The aerial dispersal of granules has been discussed. DDT has also been successfully used by dispersion as a smoke or thermal aerosol produced by injecting DDT solutions into an extension of the plane's exhaust pipe. The fine particles produced were especially effective against anopheline larvae at very low dosages, but the amount lost by drift was so great that the smoke proved less satisfactory than sprays.

Prehatching treatments have been made possible by the long-lasting qualities of DDT. It was found that 1 to 2 pounds of DDT per acre, applied to fresh-water or salt-marsh areas prior to flooding, would prevent the development of successive broods of *Aedes* as they hatch. Such treatments have been effective over an entire season. For this type of treatment the wettable powder is perhaps the most effective, although the other DDT formulations have also proved satisfactory.

Benzene hexachloride, lindane, chlordane, dieldrin, toxaphene, and heptachlor are among the other chlorinated hydrocarbons that have been successfully employed as mosquito larvicides. Dosages of 0.05 to 0.1 pound of lindane per acre, or of the gamma isomer if the crude benzene hexachloride is used, have given satisfactory control of various species, including salt-marsh mosquitoes. Dieldrin and heptachlor are about equally effective, and chlordane and toxaphene slightly less so. Toxaphene, chlordane, and dieldrin are

extremely toxic to fish, and should not be used where fish are important.

A number of organophosphorus compounds are highly toxic to mosquito larvae and several have been used in practical control programs. Parathion is one of the most effective. It is usually applied at 0.1 pound per acre, although it has sometimes been effective at lower dosages. Parathion and malathion sprays have been used extensively and safely by the California Bureau of Vector Control and by mosquito abatement districts in that State to control DDT-resistant *Culex tarsalis*, *Aedes nigromaculis* (Ludl.) and *A. dorsalis* in irrigated pastures. Applications of granular parathion have been made for the control of resistant salt-marsh mosquitoes in Florida. EPN has also been highly effective, but has not found wide use since it is marketed only as a wettable powder. Other organophosphorus compounds that have shown promise as larvicides, but are still in the process of evaluation, are Dipterex, Co-Ral, dicapthon, American Cyanamid 12008, ronnel, Phosdrin, and Bayer 29493 (Baytex).

A pyrethrum emulsion known as the New Jersey mosquito larvicide has long been used successfully against fresh- and salt-water species. The formula in concentrated form contains 66 percent of kerosene or similar petroleum distillate, 0.07 percent of pyrethrins, and 0.5 percent of a neutral emulsifier in water. One part of the concentrate is diluted with nine parts of water and applied at the rate of 15 to 25 gallons per acre. Because of its safety to fish and aquatic plants it is recommended for use in fish pools and similar places where other larvicides may prove harmful.

Petroleum oils are the first chemicals known to have been used in efforts to control mosquito larvae. They are effective against nearly all species of economic importance. Diesel oil, No. 2 fuel oil, and kerosene—the products most widely used—are comparatively inexpensive and readily obtainable. However, they must be applied in relatively large quantities, they may constitute a fire hazard under some conditions, and may be injurious to fish and wildlife if improperly used.

Paris green is highly toxic as a stomach poison to mosquito larvae (*11*) and before the advent of DDT was used extensively in the control of anopheline mosquitoes. An interesting development, in which paris green is incorporated in a granular vermiculite formulation, has been reported by Rogers and Rathburn (*267a*). It appears to be of considerable potential value against culicine larvae, especially where resistance to organic insecticides has developed.

Natural Enemies of Larvae

Various kinds of insects and other animals prey upon mosquito larvae and undoubtedly destroy large numbers. Of the many natural enemies, however, only the small larva-eating fishes have been found of practical use in control. In the Southern States the most important of these is the top-water minnow (*Gambusia affinis holbrooki*), which occurs in both fresh and brackish water. These fish are most effective against subsurface-feeding larvae and in places where the larvae are not protected by aquatic vegeta-

tion. They have been used to stock ornamental pools and other isolated bodies of water. They are highly useful in permanent ponds and in the salt marshes. Proper ditching and impounding will aid in making the best use of fish in marsh areas. The International Health Board of the Rockefeller Foundation (*267*) has prepared a review of the literature up to 1924 on the use of fish for mosquito control, and Hinman (*152, 153*) has given numerous references on other predators of mosquitoes.

Different aquatic plants are claimed to be of value in eliminating mosquito breeding. One species of *Chara* (*C. fragilis*) appears to exert a deterrent effect, although certain other species of this genus have been found to be innocuous. The bladderworts (*Utricularia*) capture and destroy small aquatic animals, including mosquito larvae. Duckweed (*Lemna*) and similar floating plants (*Azolla* and *Wolffia*) may form such dense mats on the water surface that they act as mechanical barriers to mosquito breeding, although *Anopheles* and *Culex* larvae are found in abundance when the growth is scattered. Water-hyacinth (*Piaropus*) may also act in somewhat the same way. Matheson (*212*) gives a review of the literature on this subject.

CONTROL OF ADULT MOSQUITOES

Screens, bed nets, contact and residual sprays, repellents, smudges, and fumigants are all employed for protection against mosquito annoyance. Certain birds, bats, and predaceous insects prey upon mosquitoes, but seem of little practical value in control.

In the screening of houses, galvanized or copper screens are used and the 16-mesh screen has come to be standard for this purpose. Copper (or bronze) screens, although higher in first cost, are the most durable, especially in the vicinity of salt water. Monel-metal, aluminium, and plastic screens have also been recommended in such situations. To be effective, the screening must be carefully done and special attention paid to the fitting of door and window frames, as mosquitoes will find entrance through very small openings. Bed nets made of open-mesh cloth are used extensively in some localities in the absence of, or to supplement, screening. They are frequently employed for the protection of individuals, especially in malarious or salt-marsh areas. To be of value they should be in good repair and carefully adjusted.

The advent of DDT and other residual insecticides during and after World War II opened up possibilities of controlling adult mosquitoes which previously would have been considered fantastic. Large outdoor areas can now be freed of these pests by applications of the new insecticides with modern spray equipment; homes and other buildings can be treated effectively and quickly with insecticidal aerosols; and perhaps most important of all, residual insecticides, when sprayed on the interior walls of buildings and other resting places of adult mosquitoes, give effective control over long periods. To this characteristic is due the principal credit for the elimination of malaria transmission from several countries, including the United States, where our economic loss from this disease was estimated to be $500,000,000 per year as late as 1938 (*327*). Because of these phenomenal results, plans are now being

developed by the World Health Organization looking toward the stupendous task of world-wide malaria eradication. The future outlook for use of these materials is not all rosy, however, for the phenomenon of resistance develops in some anopheline species as well as in species of other genera after continued use of these insecticides. This situation makes it imperative that the materials be used according to the best procedures devised, and also that research be continued to keep abreast of the problem through the development of new chemicals, formulations, and application techniques.

Control of Mosquitoes in Buildings and Shelters

Before World War II the principal insecticide used against adult mosquitoes was pyrethrum, although certain thiocyanate insecticides were also employed. Commercial sprays and equipment developed for household use provided much relief for the individual in his home. In Africa and India pyrethrum sprays were used in huts and houses to control malaria (*3*).

The high-pressure pyrethrum aerosol, which was devised by Goodhue and Sullivan (*128*) of the former Bureau of Entomology and Plant Quarantine and developed in cooperation with the Army and Navy, provided a revolutionary and convenient method of dispersing insecticides in air. Later, low-pressure bombs were produced, and now a variety of insecticides and synergists are used to provide quick knockdown and kill of the mosquitoes within an enclosed space.

Early in 1943 members of the Orlando laboratory staff noted the unusual residual properties of DDT in the control of adult mosquitoes (*119, 204*) and, as a result of tests in Arkansas (*120*), reported that dosages of 50 to 200 mg. per square foot in buildings and other resting places gave effective control of *Anopheles quadrimaculatus* through the entire 5-month observation period. Various agencies participated in the development and practical application of DDT as an adulticide. The application of DDT residues in buildings has been the principal or only method used in several successful campaigns against mosquito-borne diseases.

Residual applications of DDT in buildings are usually made at 200 mg. per square foot, from oil solutions, emulsions, or suspensions of wettable powder. One gallon of a 5-percent solution or emulsion is usually applied for each 1,000 square feet of surface. When suspensions are used, a concentration of 3.75 percent of DDT from a 75-percent wettable powder is recommended to reduce clogging of the nozzle, and the rate is increased to 1⅓ gallons per 1,000 square feet.

Chlordane at 2 percent and lindane at 1 percent are effective in residual sprays against mosquitoes. Both exhibit considerable vapor toxicity, but are not nearly so long-lasting as DDT. Dieldrin at 0.5 percent is also highly effective, and is longer lasting than lindane or chlordane, but is also more toxic to mammals. Crude benzene hexachloride is sometimes used in place of lindane, at equal concentrations of the gamma isomer, when the advantage of lower cost outweighs the disadvantage of stronger odor.

Some species of mosquitoes have developed physiological or be-

havioral resistance to DDT and other chlorinated hydrocarbon insecticides, leading to increased interest in the organophosphorus and carbamate compounds as residual treatments. Laboratory tests have demonstrated that parathion, Diazinon, malathion, Bayer 29493 (Baytex), Hercules AC 5727, and other compounds of this group do provide effective residues, and some are sufficiently safe to give promise of future usefulness. Malathion has been effective in field tests against *Anopheles quadrimaculatus*.

Control of Mosquitoes Outdoors

Before World War II, studies in New Jersey (*123, 124, 313*) demonstrated that people at outdoor gatherings could be protected from much annoyance by a thorough spraying of the grounds and surrounding vegetation with pyrethrum emulsions. Knipling (*204*) reported early experiments showing that DDT was effective as an outdoor residual insecticide on vegetation, or as a contact spray applied from the ground or the air. In recent years DDT and other newer compounds have been employed to destroy adult mosquitoes over large areas. Airplane spraying is particularly well adapted to this purpose, and special equipment has been devised for treating fairly large areas from the ground.

In early tests in small plots against salt-marsh mosquitoes in Florida, residual applications of 3 to 5 gallons per acre of oil or emulsion sprays containing 5 percent of DDT greatly reduced the mosquitoes for several weeks. In later tests, DDT at 2 pounds per acre in 50 gallons of emulsion was effective only 3 days (*310*), and it was believed that resistance may have been a factor in the reduced period of protection. In the later tests, lindane and BHC (40 percent of gamma isomer) applied at ½ pound per acre caused great reductions for about 2 weeks. In these tests the degree of protection in small treated areas varied with the number of migrating mosquitoes and the time required for the insecticides to exert their residual toxicity.

Residual applications have been used with some success to form barrier belts around larval breeding areas, and thus kill the adult mosquitoes as they penetrate the belt on their migratory flights.

Contact, or space, sprays for the destruction of adult mosquitoes have been widely used on a practical scale, more often in the abatement of mosquito annoyance than in disease-control programs. DDT is the insecticide most often used and the application rate is usually 0.1 to 0.3 pound per acre. The material is distributed in the form of an emulsion or oil solution containing from 1 to 20 percent of DDT, depending upon the dispersal equipment utilized. Air-drifted fogs and smokes are effective under suitable weather conditions.

As resistance to DDT has developed in certain species of mosquitoes, attention was given to alternate insecticides. Benzene hexachloride was demonstrated by Deonier *et al.* (*86*) to be effective for the control of DDT-resistant salt-marsh mosquitoes. A dosage of 0.05 to 0.1 pound of the gamma isomer per acre is required under most conditions. Later, however, salt-marsh mosquitoes in some Florida localities also developed resistance to benzene hexachloride after it had been used for several seasons.

Malathion was reported to be effective against *Aedes nigromaculis* in California and against the DDT- and BHC-resistant salt-marsh mosquitoes in Florida. Dosages of 0.1 pound per acre are effective under ideal conditions, but usually 0.25 to 0.5 pound is required. Increased resistance to malathion in *Culex tarsalis* has been reported from California (*126*). Dibrom and Bayer 29493 (Baytex) have also shown promise in small-scale field tests.

INSECTICIDE DISPERSAL EQUIPMENT

The various items of equipment found useful in the chemical control of mosquitoes are discussed in some detail in publications by the U. S. Department of Agriculture and American Mosquito Control Association (*2, 3, 310*), and will be reviewed only briefly.

Liquefied-gas aerosol bombs are most useful in providing temporary and local relief by killing the adult mosquitoes in houses, tents, or other enclosures. They may also be used to eliminate mosquitoes temporarily from small outdoor areas.

Hand-operated, compressed-air sprayers of 1- to 3-gallon capacity are convenient for the application of residual treatments inside houses or other buildings (pl. 1B) and for larviciding small areas, especially in the control of domestic mosquitoes. Hand-operated atomizers and bucket pumps may be used in the same way. Larger, power-operated sprayers, mounted on vehicles and supplied with sufficient lengths of hose, may be used to advantage in applying residual treatments inside a large group of buildings, residual or contact sprays to outdoor areas, or for the larviciding of areas accessible to the vehicle. A fan-type nozzle is preferable for residual applications, but a cone-type nozzle may be used.

Several types of mist blowers and thermal fog generators have been developed especially for the control of flying insects. In one type of mist blower the liquid is pumped at low pressure to the spray head, where it is delivered into the center of a high-speed air blast (pl. 3A). Although the primary use of the machine is to provide an adulticidal contact spray in outdoor areas, the output is sufficient to provide some residual action. The machine may also be used for larvicide applications, especially where the breeding places are fairly wide and best covered by a wind-drifted spray. In another type of mist blower, the Microsol (pl. 3B) the spray is finely atomized by means of spinning disks and then dispersed by an air blast. This machine is sometimes called a mechanical aerosol generator, but the droplets fall more nearly into the category of a mist; that is, greater than 50 microns in diameter. A small electric model for use in buildings is said to give a large proportion of droplets within the aerosol range. A power pneumatic sprayer designed by Husman (*171*) for outdoor use provides particles in both the aerosol and mist ranges.

In the thermal fog generator (pl. 4A) heat is employed to break up the liquid into fine droplets, which are drifted across country as dense fogs to control adult mosquitoes. Several machines based on this principle, such as the TIFA, Dyna-fog, and Swing Fog, are available. The heated exhaust gas from motor vehicle has been utilized for the production of insecticidal smoke. The particles in fogs and smokes are very small and remain airborne much longer than particles in most sprays. For this reason

they are at the mercy of atmospheric conditions and may show variable results. In moderate breezes the fog may be carried long distances, and in rising air currents it will rise above the lower levels where the mosquitoes are resting or flying. On the other hand, with a light breeze in a favorable direction and with air movements toward the ground, which occurs when the temperature of the ground is lower than that of the air (inversion conditions), fog drifting slowly through an area may be highly effective.

Hand-operated or power-driven dusters may be utilized for larvicidal operations. No special equipment is available for applying larvicidal granules from the ground.

Airplanes were first employed experimentally in 1923 by members of the then Bureau of Entomology (*187, 188*) for the control of malaria mosquito larvae with paris green dusts, and were subsequently used by the Tennessee Valley Authority and other agencies. The newer, more potent insecticides are especially adaptable to airplane dispersal as sprays or granules.

The first airplane spray equipment developed and tested with DDT solutions was designed for use on an L-4 (Piper Cub) airplane. In this model, known as the Husman-Longcoy spray unit, the insecticide was dispersed through six nozzles on the trailing edge of a venturi beneath the fuselage. Soon afterward, an underwing spray boom was developed and used both on monoplanes of the L-4 type and biplanes of the PT-17 (N 25 Stearman) type (pl. 4B). Openings of a suitable size were drilled in the boom, and a breaker bar was mounted behind the boom to increase the breakup of the droplets. Spray nozzles were also used on the spray booms in place of the drilled holes and breaker bar.

After World War II large numbers of surplus training planes, principally PT-17's, became available, and most of the civilian mosquito-control work has been done with planes of this type. Larger planes, particularly C-47's, have been used in military operations. Spray equipment of this type is used in adulticiding and larviciding programs.

Airplanes equipped for dusting agricultural crops are sometimes utilized in the application of larvicidal dusts. With slight modifications in the hoppers, dusting planes are readily adapted to the dispersal of granules—an efficient method of larviciding in breeding areas covered with vegetation.

Insecticidal smokes, produced by injecting DDT solutions into an extension of the plane's exhaust pipe, have been used in some larviciding operations, but are usually less effective than sprays. Malathion smokes give high kills of adult mosquitoes.

MOSQUITO REPELLENTS

Various essential oils, such as citronella, have long been used to protect individuals from mosquito bites, but systematic investigations of repellents were not undertaken until a comparatively recent date. In 1940 Granett (*129*) reported a suitable procedure for the critical evaluation of repellents, and summarized the results with a series of nearly 1,000 materials. A mixture of organic compounds was superior to citronella and the other oils, and a

large field of investigation was suggested. In 1945 Granett (*130*) reported the effectiveness of ethyl hexanediol as a mosquito repellent, and in 1946 Travis *et al.* (*307, 308*) summarized the research at Orlando that led to recommendations for the repellents used by the Armed Forces during World War II. The results of screening tests with thousands of compounds as mosquito repellents were compiled by King (*186*), and studies in which the better repellents were tested against a variety of species have been reported by various workers at Orlando (*309, 122*).

Diethyltoluamide is the most effective of the mosquito repellents and is satisfactory for application to the skin or clothing. It gives protection against a wide range of species, and when applied to the skin it repels for longer periods than other materials, and is more resistant to removal by rubbing or wiping. Technical diethyltoluamide contains various proportions of the meta, ortho, and para isomers. The meta isomer is the most effective, and should make up the major portion of products used as mosquito repellents.

Ethyl hexanediol, dimethyl phthalate, and dimethyl carbate also are highly effective and are safe for general use on the skin or clothing. Each of these chemicals is outstanding against certain species of insects, but varies in its effectiveness on different persons. The following mixture of these compounds has been found effective against a wider range of species, under more widely divergent climatic conditions, and on more individuals than the single compounds (figures in parts by weight) :

Formula M-2020

Dimethyl phthalate	4
Dimethyl carbate	3
Ethyl hexanediol	3

Although toxicologists have found these repellents safe for use on skin, some persons may be allergic to them. Any of the repellents may cause some smarting when applied to the mucous membranes or to areas where the skin is especially tender, such as the eyelids. Sometimes the treated skin will at first feel warm, especially if it is moist with sweat, but usually the sensation lasts only a few minutes and causes no injury. Repellents cause a severe but temporary stinging if they get into the eyes, and therefore should not be applied too liberally on the forehead. A 50-percent solution of diethyltoluamide in alcohol is the most acceptable cosmetically, having little or no greasy feeling on the skin. These repellents affect paints, varnishes, some types of synthetic cloth (rayon but not nylon), and many of the plastics to varying degrees. They will not damage cotton or wool cloth if it contains no synthetic fibers. Ethyl hexanediol has the least effect on painted surfaces; diethyltoluamide is also much less injurious than the other materials, and usually causes no appreciable injury to plastics. For this reason many persons prefer to use one of these materials alone rather than one of the mixtures.

For the best results, a repellent must be uniformly distributed over the entire area to be protected, for the insects will discover and bite in any small spot that is not covered. The most common method is to shake a few drops from the bottle into the palms

of the hands, smear evenly, and then apply thoroughly to the backs of the hands, wrists, neck, ears, face, or any other exposed skin, much as in washing. Sufficient repellent should be applied to give a uniform film. All these repellents except 50-percent solutions of diethyltoluamide in alcohol feel oily to the skin, and may therefore be objectionable to some individuals. However, the protection they afford from biting insects more than compensates for this oiliness. Under favorable conditions one treatment will last several hours on most people, but should be repeated when the insects resume biting.

These repellents can be used also to keep mosquitoes from biting through the clothing. Properly treated clothing will give protection for several days. One soaking with water, however, destroys the repellent action. The repellent can be sprayed or daubed on the clothing only in areas where the bites occur, such as across the shoulders and along the thighs, but the best method of obtaining protection under all conditions of exposure is to impregnate all the outer clothing that will be worn in the field. Use about $\frac{1}{15}$ ounce per square foot of cloth, or a total of $2\frac{1}{2}$ ounces (5 tablespoonfuls) to a jacket (or shirt), trousers, and socks of medium size. Do not treat the underwear. Dissolve the repellent in enough dry-cleaning fluid to wet the garments thoroughly without any excess, about 3 pints for an outfit of heavy cotton cloth being required. After all parts of the garment have been saturated with the solution, allow the cleaning fluid to evaporate.

An emulsion can be made by mixing $2\frac{1}{2}$ ounces (5 tablespoonfuls) of the repellent with 3 pints of water and $\frac{1}{4}$ ounce ($1\frac{1}{2}$ teaspoonfuls) of an emulsifier or 1 ounce (2 tablespoonfuls) of soap. Suitable emulsifiers are Stearate 61-C-2280 (a polyalkylene glycol stearate); Tween 80 (sorbitan monooleate, polyalkylene derivative); and a polymerized glycol monostearate, monooleate, or monolaurate. Many synthetic household detergents are not suitable for making emulsions, but most laundry soaps are satisfactory. Dissolve the emulsifier or soap in the water and add the repellent slowly while stirring vigorously. If large quantities of clothing are to be treated, a stock solution containing 90 percent of the repellent and 10 percent of emulsifier can be prepared, and added to water as needed at the rate of $\frac{1}{2}$ pint to 1 gallon. Saturate all parts of the garments with the emulsion, wring lightly, and dry thoroughly before wearing.

The most effective repellents for treatment of clothing are diethyltoluamide, and 2-butyl-2-ethyl-1,3-propanediol. The latter compound is a solid at normal temperatures and is best applied by the impregnation method as a solution. It should not be applied to the skin.

SPECIFIC PROBLEMS

A few notes are given below in regard to problems of control of some of the more important mosquito species.

The Common Malaria Mosquito

(*Anopheles quadrimaculatus*)

This species develops principally in more or less permanent

bodies of fresh water such as pools, ponds, and marshes containing vegetation and floating debris, shallow vegetated lake margins, and places of like nature (pl. 5). Such situations occur frequently in and adjacent to rural settlements and small towns, which become infested with large concentrations of *quadrimaculatus* as a result. Because of this situation, malaria in the Southeastern States occurred to a greater extent in these smaller communities than in more favorably located cities, or towns where municipal developments had destroyed the breeding places. As has been discussed elsewhere, this disease was virtually eradicated from the United States as a result of a comprehensive program carried out by Federal and State health agencies in which DDT residual home spraying in malarious areas was the principal means, larvicides being employed but rarely. Nevertheless, it may be well to give continuing attention to programs for the reduction of this vector as it often becomes sufficiently abundant to be a serious pest and would present a disease hazard should any resurgence of malaria occur.

The older chemical larvicides, such as oils and paris green, used for treating anopheline breeding areas that cannot otherwise be cared for, will not be discussed here, since they are treated adequately in other literature (*79, 181, 318, 328*), and they now have been superseded by DDT and other modern larvicides, which have been discussed in the preceding sections. It may be appropriate to mention here, however, that the use of airplanes in mosquito control was first developed by the senior writers in 1923-24 in connection with applying paris green dusts for the control of *quadrimaculatus* (*187, 188*). With the development of resistance to organic insecticides, the use of paris green may again be of great value in an anopheline control program.

A. quadrimaculatus enters houses to obtain blood meals from humans, and seeks shelter in dark cool situations within doors during the day. When these daytime haunts are coated with lethal applications of DDT or other residual insecticides, mosquitoes which come in to rest are killed. Thus, while the overall reduction in the mosquito population present in the area may be negligible, this selective killing of individuals that have fed on man and may be infected with malaria parasites breaks the chain of transmission.

Procedures and formulations for the application of residual sprays are discussed under the section Mosquito Control.

A. quadrimaculatus does not ordinarily fly long distances and the control of breeding within a 1-mile radius of a populated area has so reduced the numbers of mosquitoes as to prevent malaria transmission in such communities (*12, 121, 206, 207*). In this work the first essential is the permanent elimination of low, swampy places by filling or drainage. Ditches and the margins of the deeper ponds and lakes should be kept free of vegetation. Breeding in shallow ponds full of aquatic growth, or in the beds of occasionally flowing streams can sometimes be controlled economically by impounding the water with dams to a depth sufficient to overcome the aquatic vegetation (pl. 2). Periodic fluctuation of the water level in such impounded areas is important in reducing the marginal growth and flotage. The impoundage of

large bodies of water for hydroelectric or other purposes, however, has introduced serious problems in malaria control, and special legislation has been enacted by Southern States covering the measures that must be taken to prevent breeding of anopheline mosquitoes in such projects. The Tennessee Valley Authority found it necessary to provide for an extensive program of *Anopheles* control in the impounded areas on the Tennessee River (*29*). As this work progressed it proved essential to establish minimum requirements as to reservoir preparation and shoreline improvement with special reference to vegetation control, and to provide for adequate water-fluctuation schedules (*155, 301*).

The Domestic Mosquitoes

(*Aedes aegypti* and *Culex pipiens quinquefasciatus*)

Urban antimosquito campaigns usually combine control measures against the yellow-fever and the southern house mosquitoes, and, although their practical control offers no unsurmountable difficulties, continuous efforts and expense are required to keep the numbers reduced. These species differ in breeding habits. *Culex p. quinquefasciatus* breeds especially in polluted waters and ground pools. Rain barrels and similar water containers are important breeding places for both. Where the water in these receptacles is required for domestic purposes, the barrels should be kept tightly covered and the water drawn from a spigot at the bottom; otherwise, they require weekly emptying or treatment with a larvicide, either of which is likely to be neglected. When larvae are present, spraying the surface with a small amount of kerosene or a pyrethrum fly spray is effective, and imparts little odor to the water. Fire barrels should be treated with DDT or some other effective larvicide. Tubs and other casual water containers left in the yard should be turned upside down when not in use, and worn-out equipment should be disposed of.

With the yellow-fever mosquito (*Aedes aegypti*), the smaller water containers, such as old cans, bottles, flower vases, and obstructed eaves troughs, are important, and a campaign against this species should begin with a clean-up of yards and vacant lots. During the dengue-fever-control work in Florida in 1934, a large proportion of the discarded automobile tire casings left in the open were found to contain water with *aegypti* larvae, and many breeding places were found in automobile-wrecking yards. Toilet bowls and flush-tanks in vacant houses and apartments require systematic attention, and collections of water in the basements of buildings should not be overlooked. The adults of this species do not fly far, and when they become troublesome at any point the breeding source can usually be found on the premises or nearby. An essential part of any *aegypti* control program is the frequent and thorough inspection of premises by well-trained men. If, for any reason, breeding sources cannot be eliminated, they should be sprayed or dusted with a larvicide such as DDT. By intensive antilarval measures, *aegypti* has been eradicated from large areas, even entire countries, in South America. An eradication program from the Western Hemisphere, including the United States, is now under consideration by public health workers.

One of the most prolific sources of production for the southern house mosquito (*Culex p. quinquefasciatus*) in cities or towns, is the storm-sewer catch basin, which is designed almost universally with a watertight debris trap below the level of the outlet. The larvae of *Aedes aegypti* also have been found in these places. In an antimosquito program the catch basins are usually treated with a larvicide periodically by the use of special equipment installed on trucks or motorcycles. Other important sources of mass production of *C. p. quinquefasciatus* are open cesspools, badly drained street gutters, and polluted ground pools, especially around city dumps or sewage outlets. Wherever possible these breeding places should be eliminated permanently by drainage, or the cesspools effectively covered; otherwise they require frequent treatments with larvicides.

Waste water from food-processing plants or industrial operations, and occasionally the effluent from inefficiently operated sewage-disposal systems, provides ideal breeding conditions if allowed to collect in pools or sluggish, weed-grown streams. Larvicidal treatment of such collections of water serves to abate the immediate mosquito nuisance. Many State and Federal agencies are active in the development of measures to eliminate the pollution of streams and ponds from such sources.

Salt-Marsh Mosquitoes

(Principally *Aedes sollicitans* and *A. taeniorhynchus*)

The salt-marsh mosquitoes fly extremely long distances. Migratory swarms have been observed 40 miles or more from their breeding places, although the average length of flight is, of course, much less. Because of their great flight range, local work against these species may be of little benefit, and control programs are usually undertaken on a countywide basis. Generally, the actual control work should begin on the breeding marshes nearest the population centers, and should progress outwardly until the desired results are obtained.

Investigations and control work against the salt-marsh species were begun in New Jersey more than 50 years ago, and New Jersey's example has been followed by most of the North Atlantic States. On the South Atlantic and Gulf Coasts, except in a few counties in Florida, no large-scale operations had been attempted prior to 1933, when advantage was taken of the opportunity offered by the programs of the Federal Emergency Relief and the Civil Works Administrations. By 1957 all but one of the coastal counties in Florida had established antimosquito districts.

Mosquito-breeding conditions in salt marshes and the methods employed to overcome them are extremely varied. In general, the mosquitoes breed on the parts of the marsh that are not covered by daily tides, usually in potholes and depressions of various sizes, but sometimes over extensive level areas (pl. 6A). By the usual control practices, a system of ditches (pl. 7) is installed (1) to provide for a fairly rapid run-off of surface water following the occurrence of heavy rainfall or of high storm tides, (2) to permit free circulation of tidal water into low areas that are otherwise landlocked, and (3) to give larva-eating minnows ac-

cess to the pools and ponds or other places where the larvae accumulate as the surface water is drained off.

The ditch system on any marsh should be designed to give the maximum degree of mosquito control with the least amount of ditching. The system for each marsh should be determined by the conditions presented, and stereotyped drainage systems should be avoided. Preliminary surveys are necessary to determine any natural drainage and to locate the waterholding, mosquito-breeding areas. The natural channels should then be improved and the ditches located so that they will extend from these channels to the breeding portions of the marsh, following the lowest contours. In general, the ditches should not be cut directly into ponds, but rather connected by short spurs, since it is often difficult to maintain the desired depth in the soft mud of the pond bottoms. On large marshes which are so flat that natural drainage is negligible or difficult to discern, the usual practice is to place the ditches in a parallel system at intervals of 100 to 300 feet, with main outlet ditches as needed. Even on such marshes, however, the amount of ditching may often be reduced by making preliminary surveys to locate the mosquito-breeding portions of the marsh and limiting control work to such areas. The installation of rim ditches for draining areas adjacent to the highland, where heavy breeding often occurs, is necessary on most marshes.

In New Jersey where the marshes are usually well sodded, the standard ditch is 10 inches wide by about 20 inches deep, with the sides perpendicular. In other areas, especially in the South, the width and depth of the ditches have to be modified to meet other soil conditions and problems incident to other types of marsh vegetation. In Florida the ditches originally installed by hand were mostly 30 to 40 inches wide. Since 1953, by virtue of its State subvention funds with emphasis on permanent measures, ditching for salt-marsh-mosquito control has been greatly extended in Florida. In order to obtain the most economical operation, hand ditching has been almost entirely replaced by machine ditching, principally with draglines. The width of machine ditches generally ranges from 2 feet in marshes underlain with rock to 15 feet in muddy flats. The majority of the dragline ditches, constructed in open marsh and mangrove, range in width from 8 to 12 feet depending on soil conditions. The short laterals extending beyond the spoil piles along the ditches may be as narrow as 4 feet, but they are usually placed at the same depth as the main ditch. Little or no attention is given to sloping the sides of machine ditches in open marsh and mangrove. The ditches are dug to a minimum depth of one foot below mean low water and are made sufficiently wide so that allowance is made for caving of the perpendicular banks and still maintaining adequate depth and width.

Various types of heavy machinery for digging and cleaning the ditches have been developed by workers in the North, and special kinds of ditching spades and other tools have been designed for use by hand labor. The type of marsh in the locality in which work is to be done should govern the selection of tools. The kinds of machine ditchers or special spades developed in New Jersey do not appear to be adapted for use in most of the south-

ern marshes. As mentioned above, a dragline of suitable size is used to advantage for large ditches or outlet canals, and backhoes, clamshells, or other types of equipment may be used in special circumstances. In most Florida marshes the draglines are operated on mats, but they can be used from barges in otherwise inaccessible areas.

Another important method of treating certain classes of marsh is the installation of dikes and tide gates to prevent the entrance of high tides. The tide gates, opening at low tide, also provide for the run-off of rain water. Under special conditions the tide gates may be reversed to permit the entrance of high tides and to impound the water on the marsh, or pumps may be used to flood the impounded areas as required. This is effective in reducing *Aedes* breeding, since it is the alternate drying and flooding of the marshes that brings about the hatching of their eggs.

Experimental work in the early 1930's by members of the Bureau of Entomology and Plant Quarantine in the vicinity of Savannah, Ga., showed that the shutting off of the tides from marshes by means of dikes and tide gates so that the marshes became dry, eliminated much breeding of the sand fly (*Culicoides*) as well as of the mosquito. It is probable that this practice can be combined with ditching in other sections where the sand fly is a serious problem.

In the southern half of Florida, where *Aedes taeniorhynchus* is the predominant salt-marsh mosquito, the marsh vegetation is dominated by growths of several species of mangrove (pl. 6, *B*). Although this presents a special clearing problem with respect to hand-ditching operations, construction of ditches with a dragline is only slightly impeded. In constructing the ditch, the dragline operator sometimes can clear his own right-of-way by swinging his dragline bucket through the growth of mangrove ahead of the machine. Dynamite ditching has been employed in such marshes and compares favorably in cost with hand labor. It is more expensive than the use of a dragline, but may be used in small areas inaccessible to these machines.

Another difficult problem is encountered in certain areas where the marshes border more or less landlocked bodies of water in which there is ordinarily little tidal range. Strong wind tides may cause a flooding of these marshes, and continuous winds may hold the water there long enough for a brood of mosquitoes to develop even though the marsh is thoroughly ditched. To meet this problem it has been proposed that such areas be diked and the water removed or the water level maintained by pumping or by artesian wells. The management of water on coastal marshes in Florida for mosquito control has been discussed by Philen and Carmichael (*246*). They also discuss vertical drainage and hydraulic fills.

The control work against salt-marsh mosquitoes, particularly in the North Atlantic States, has been criticized as unnecessarily destroying the feeding and breeding grounds of wildlife. Research by mosquito-control and conservation agencies has been directed toward providing mutually satisfactory control methods. Much progress has been made, and joint efforts are being continued. It is believed that many of the deeper ponds, as well as the plant

species that serve as food, can be saved without detriment to the antimosquito work. If the ponds are of value as feeding and resting grounds for wild fowl, the ditches may be diverted or, if they are run into the ponds, a sod dam or wooden spillgate may be inserted, somewhat lower than the marsh level, to prevent complete drainage of the pond and to permit the inflow of high tides. Deepening of the shallower ponds may be necessary to obtain surface drainage of the neighboring marsh, and should greatly increase their value and permanence. The proper management of impoundments in many such areas will result in reducing the numbers of *Aedes* while increasing the food for waterfowl (*75*).

Sump drainage may be employed to decrease mosquito breeding in small, enclosed areas where drainage is difficult, or in areas that are of special value from a conservation point of view. By this method ditches are dug so that the water is concentrated in the lowest portion of the marsh, where, if no pond or pool exists, one is excavated to serve as a reservoir for maintaining predacious

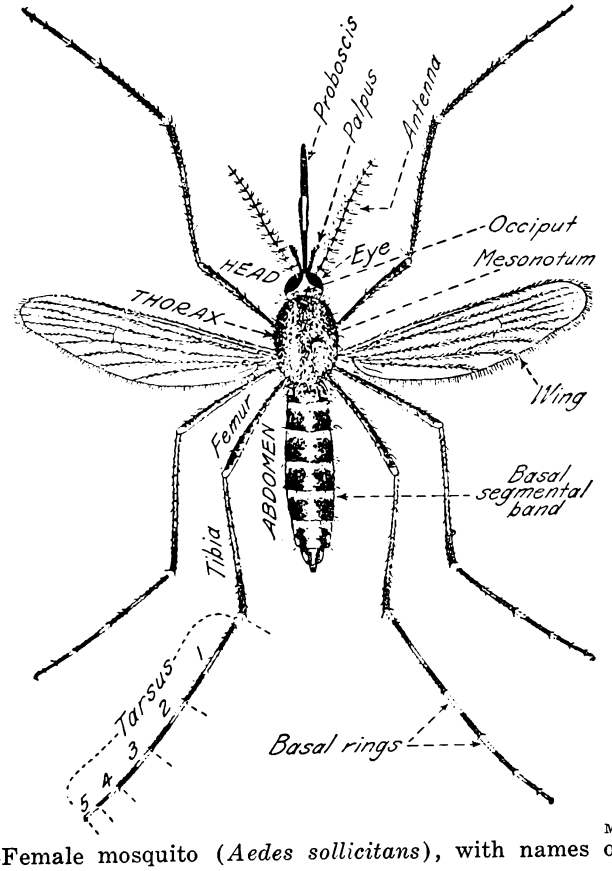
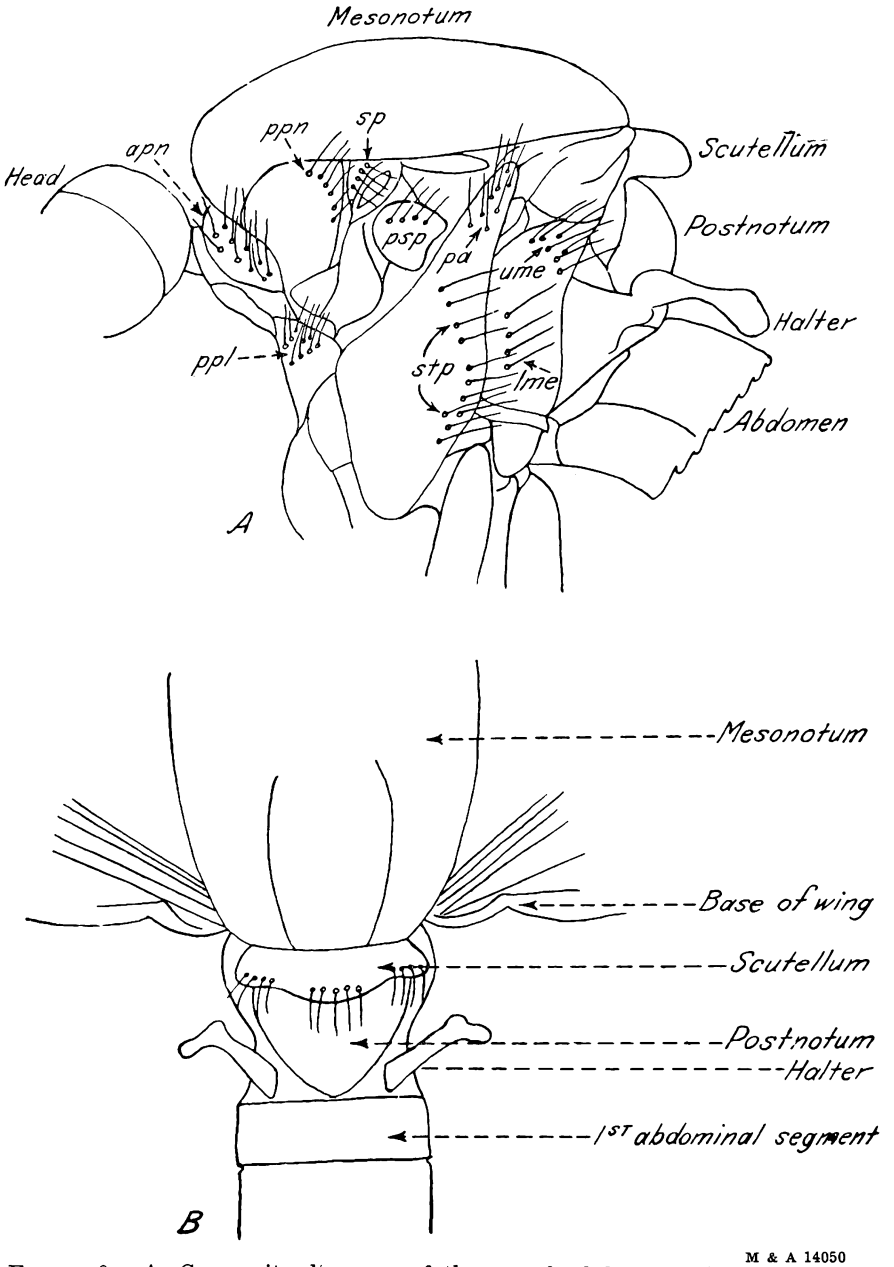


FIGURE 8.—Female mosquito (*Aedes sollicitans*), with names of the parts.

minnows and insect enemies of mosquito larvae. In successful operations, light floodings of adjacent breeding areas are drained into the sump by the ditches, and when the whole marsh becomes flooded the ditches facilitate access of the predators to all parts

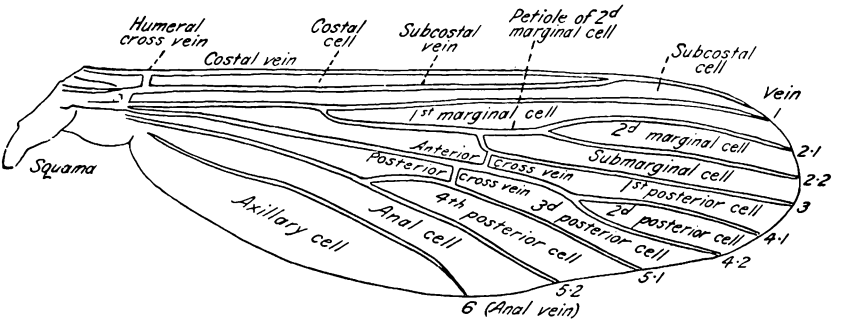
of the area. Successful use of this method was reported by Stutz[2]



M & A 14050

FIGURE 9.—A, Composite diagram of thorax of adult mosquito, showing the groups of pleural bristles: *apn*, Anterior pronotal (prothoracic); *ppn*, posterior pronotal (preepimeral); *ppl*, propleural (prosternal); *sp*, spiracular; *psp*, postspiracular; *pa*, prealar; *stp*, sternopleural; *ume*, upper mesepimeral; *lme*, lower mesepimeral. *B*, Posterior portion of thorax from above.

[2] Stutz, Fred H. Sixth Annual Report of the Broward County, Florida, Anti-Mosquito District Covering Activities for 1940. 9 pp. (Mimeographed.)

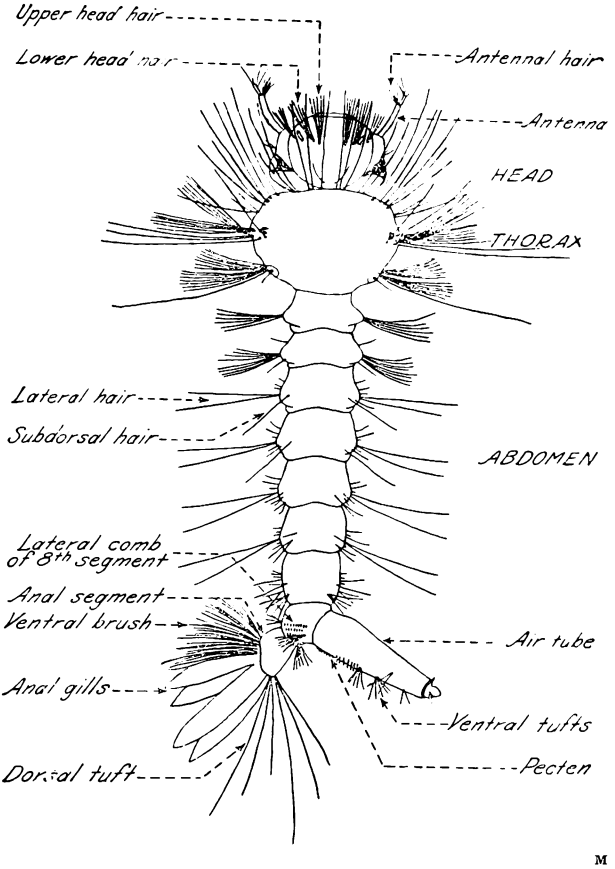


M & A 14051

FIGURE 10.—Wing of mosquito (Howard, Dyar, and Knab). The corresponding symbols for the veins in the Comstock-Needham system are: 1, R; 2.1 and 2.2, R_2 and R_3; 3, R_{1+5}; 4.1, M_{1+2}; 4.2, M_3; 5.1 and 5.2, Cu_1 and Cu_2; anterior cross vein, *r-m*; posterior (basal) cross vein, *M-cu*.

in Broward County, Fla., for controlling breeding in low subdivision squares where adequate drainage was impractical.

Another problem arises in connection with the lowering of the water table, which results sometimes in an undesirable change in



M & A 14052

FIGURE 11.—Larva of *Culex p. quinquefasciatus* with the parts named (Howard, Dyar, and Knab.)

plant species and sometimes in a subsidence of the marsh level. As such changes vary greatly with different soil and tidal conditions, a thorough study of such factors should be included in the original surveys. Where the soil texture indicates little water-holding capacity, excessive lowering of the water table may be avoided in some cases by the use of very shallow ditches.

Larvicides are employed in salt-marsh-mosquito control for the treatment of areas that are not taken care of by ditching. DDT has been used most extensively, and large areas have been protected for several years by aerial applications of this larvicide. However, salt-marsh mosquitoes have developed resistance to this insecticide and other chlorinated hydrocarbons as well. Although these larvae are susceptible to the organophosphorus compounds, the development of resistance through larviciding has led a number of mosquito-control agencies to avoid the use of larvicides and to direct their chemical control measures against the adults in inhabited areas in the belief that resistance is developed more rapidly when larvicides are used than when the treatments are limited to the adults. Where larvicides are used they are usually applied as aerial sprays, but in some mangrove marshes, and other areas covered with heavy vegetation, granules are used to provide better penetration (*118, 179*).

MOSQUITO IDENTIFICATION AND NOTES ON THE GENERA AND SPECIES

The identification of the different species requires a knowledge of mosquito anatomy, as the distinguishing characters consist of

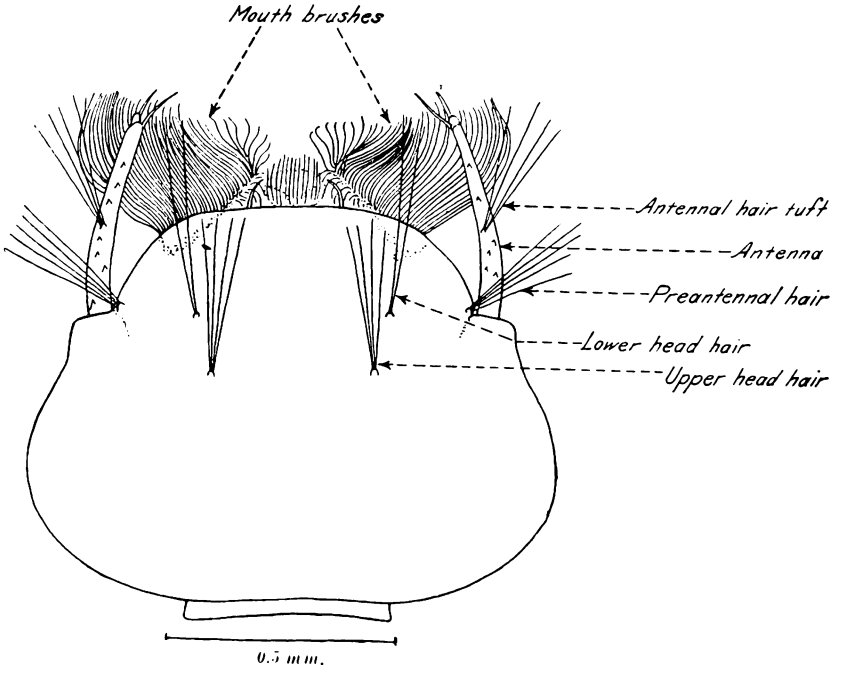


FIGURE 12.— Head of larva of *Aedes vexans.* M & A 14053

variations, frequently very slight, in shape, size, coloration, or scaling of the different parts of the body. Illustrations are provided herein to show the names and locations of the principal parts that are utilized in identification, and the diagnostic keys have been made as simple as accuracy will permit.

A binocular dissecting microscope is necessary for satisfactory examination of the external characters of adult mosquitoes. It should be provided with objectives and oculars giving magnifications up to about 75×. With high magnifications a spotlight or other source of bright illumination is required. For the examination of larvae and slide mounts of male terminalia, a compound microscope is needed and should be equipped for magnifications of about 100× and 400×. An oil-immersion objective is ordinarily used for advanced work on the male terminalia. For field work and for provisional identification of adults, a good hand lens giving a magnification of 10× to 15× is very useful. In fact, after one has become thoroughly familiar with the species of a locality, he will be able to identify many of them with the hand lens, and to recognize some of them even with the naked eye.

Workers inexperienced in systematic work with mosquitoes should have on hand, for comparative study, at least a small series of correctly identified species, which can be obtained by sending carefully prepared material to a specialist with the request that named specimens be returned. Until one has become familiar with the species, the material should in any case be forwarded to an authority for a check on the identifications when questions of control or habits are involved, since misidentifications may cause application of inappropriate control measures and result in program failures. Identifications may be obtained through the Entomology Research Division, U. S. Department of Agriculture, some of the State universities and experiment stations, or State boards of health.

The family Culicidae, which, as previously mentioned, contains the true mosquitoes, is represented in the Southeastern States by three subfamilies and eleven genera, as follows: subfamily Anophelinae with one genus, *Anopheles,* and 11 species: subfamily Toxorhynchitinae with one genus, *Toxorhynchites* (formerly *Megarhinus*), one species, and two subspecies; and subfamily Culicinae with the remaining 9 genera and 64 species and subspecies, as shown in table 1.

In the following pages a synoptic key is given for the separation of the genera; then, under each genus, a brief account of the adult and larval habits common to the genus and a brief description of the characters that help to define the genus, in addition to those used in the key. This is followed by adult and larval keys to the species of that genus, notes on the habits of each species, its relation to disease or economic importance, its known distribution, and a brief summary of the specific characters that may be of help in identification. The descriptive matter applies primarily to the species of a limited region, and variations or exceptions that may occur in other regions are not noted unless they seem to be of special interest.

In Misc. Pub. 336 (*193*) the species of all genera were combined into a single key for adults and one for larvae, because the identi-

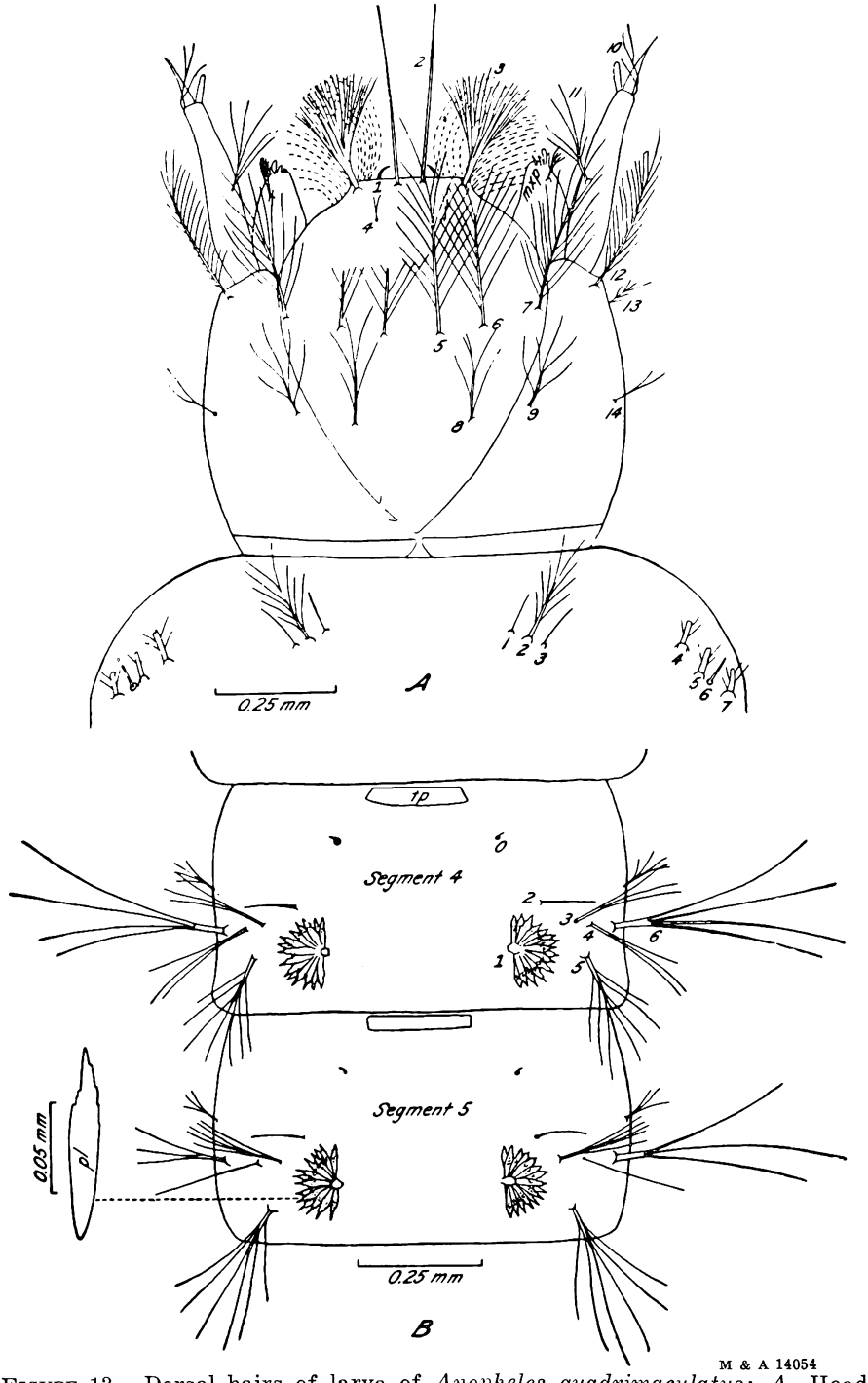


FIGURE 13.—Dorsal hairs of larva of *Anopheles quadrimaculatus*: *A*, Head and part of prothorax; *B*, abdominal segments 4 and 5. Head hairs: 1, Preclypeal; 2, inner clypeal; 3, outer clypeal; 4, postclypeal; 5-7, frontal; 8-9, inner and outer sutural (occipital); 10, terminal antennal; 11, antennal; 12, preantennal (basal); 13, subbasal; 14, orbital; mxp, maxillary palp. Prothorax: 1, Inner submedian; 2, middle submedian; 3, outer submedian; 4-7, lateral. Abdominal segment 4: O, Anterior submedian; 1, palmate; 2, antepalmate; 3-5, sublateral; 6, lateral; tp, tergal plate. Segment 5: pl, Enlarged palmate leaflet.

fication of a species is, in many cases, much easier than the identification of the genus by the usual microscopic characters. Because the number of species now known in the area has increased considerably, this method has been abandoned and separate keys to the genera have been prepared. Nevertheless, an effort has been made, so far as possible, to add characters visible with a hand lens, or at low magnification, that apply to most of the species in a genus, at least in the Southeastern States, even though they may not be strictly of generic rank.

The keys have been prepared in the usual form of opposed couplets, with the most obvious character given in the first sentence, usually followed by one or more characters that help to describe the species or group. When there is doubt as to which part of the couplet the specimen fits, it is the practice to follow out both divisions to find a later fit if possible. It may be necessary finally to compare the descriptions under several of the doubtful species. In the adult keys to species, the characters apply primarily to the females unless the male is mentioned. The males of most

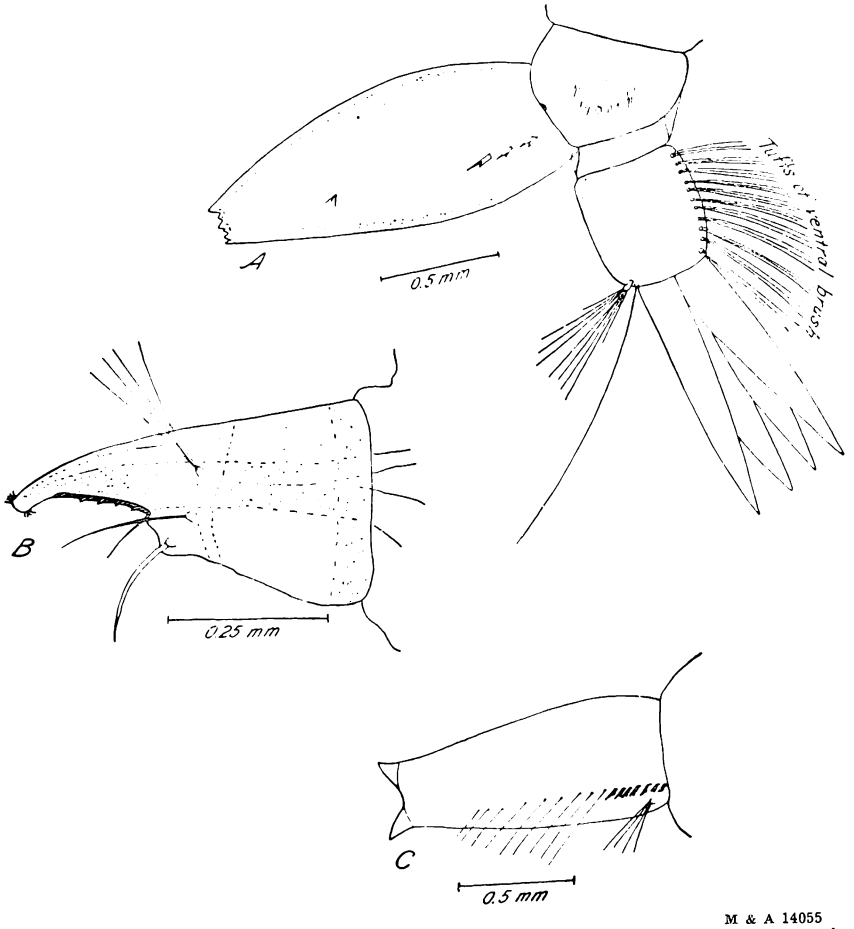


FIGURE 14.—Types of air tubes: *A*, *Psorophora ferox* (also showing terminal segments of abdomen); *B*, *Mansonia perturbans*; *C*, *Culiseta inornata*.

species can be identified by the character given although some differences occur in the distribution of pale scales. The white bands on the abdomen, for example, cannot be used satisfactorily in identifying the male of subgenus *Culex*.

The external characters and the names of the parts employed in the descriptions of adult mosquitoes are shown in figures 8, 9, and 10, while those for the larvae are shown in figures 11 to 16.

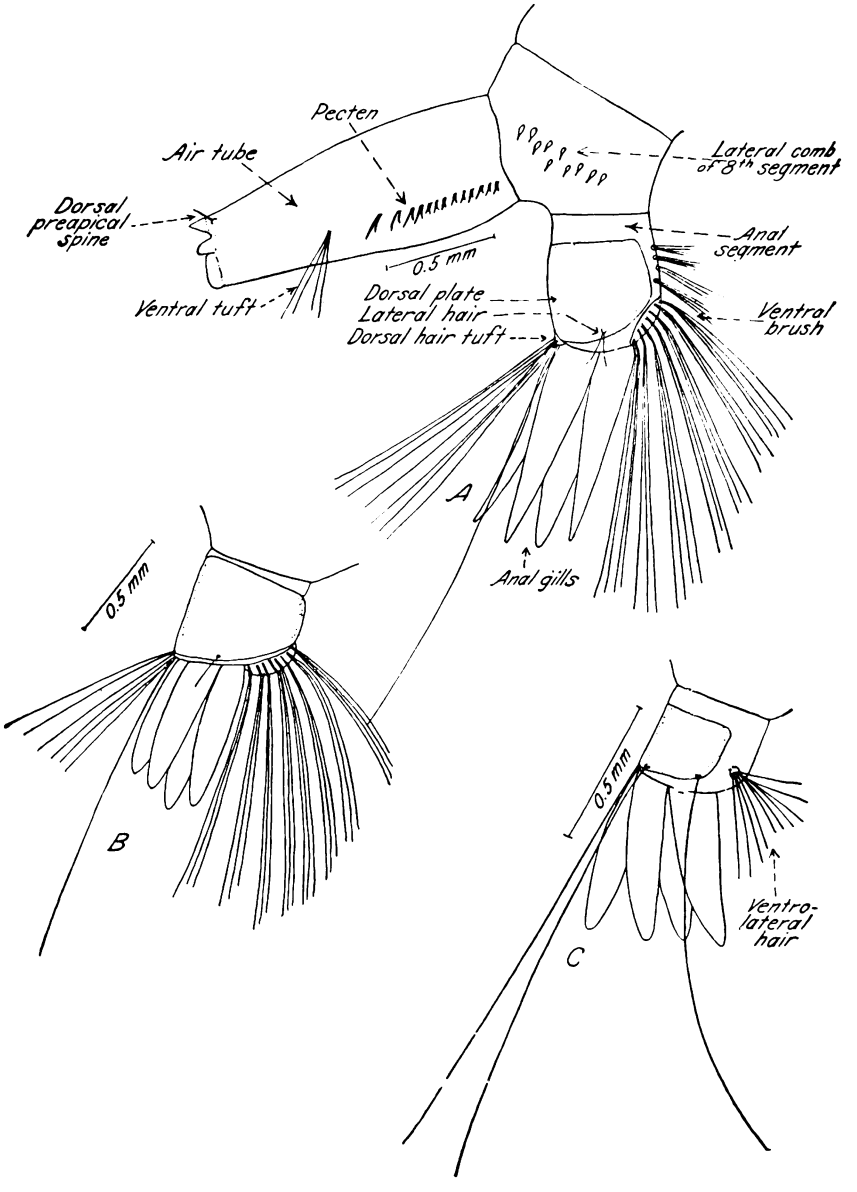
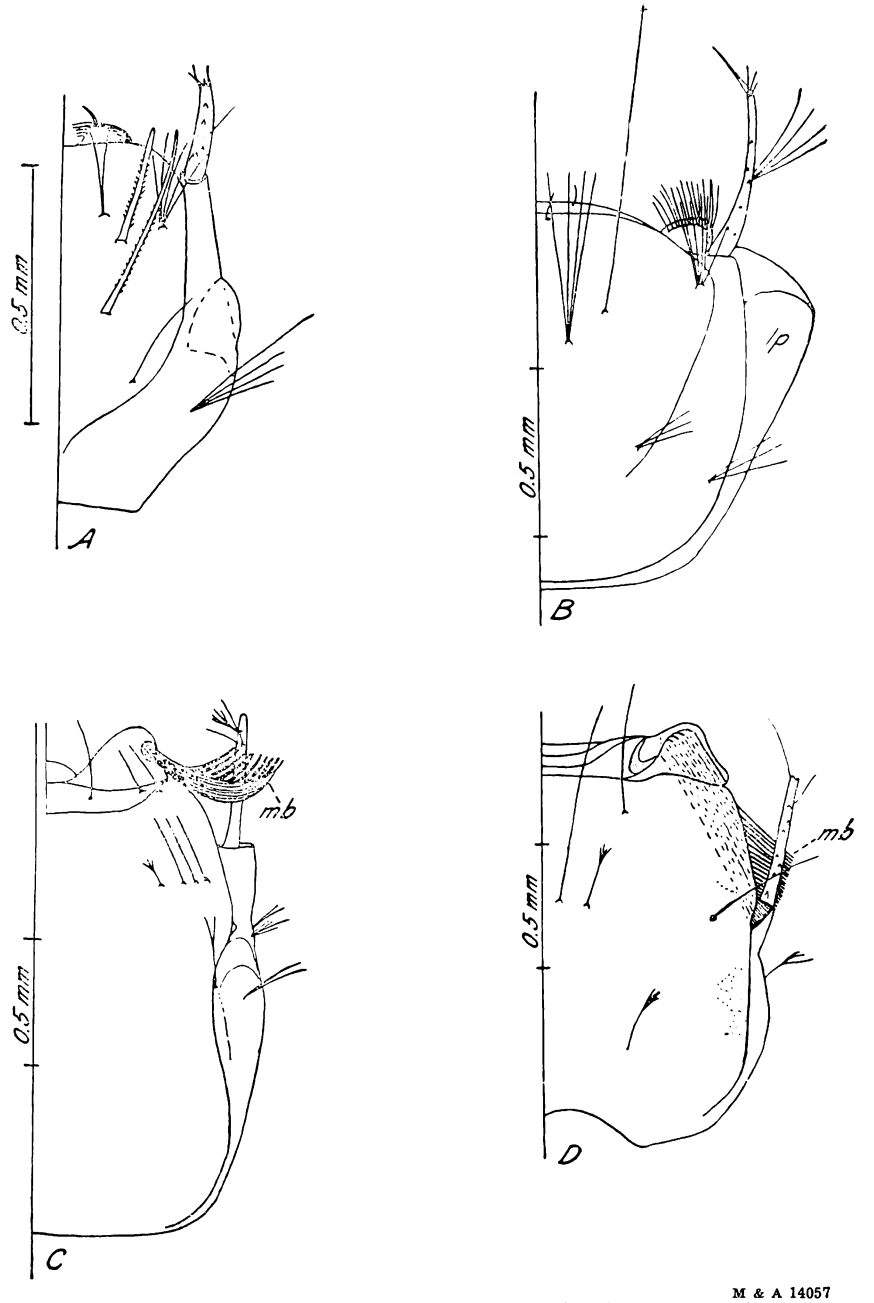


FIGURE 15.—*A*, Posterior portion of abdomen of larva of *Aedes vexans*; *B*, anal segment of larva of *Aedes mitchellae*; *C*, same of *Wyeomyia mitchellii*. M & A 14056



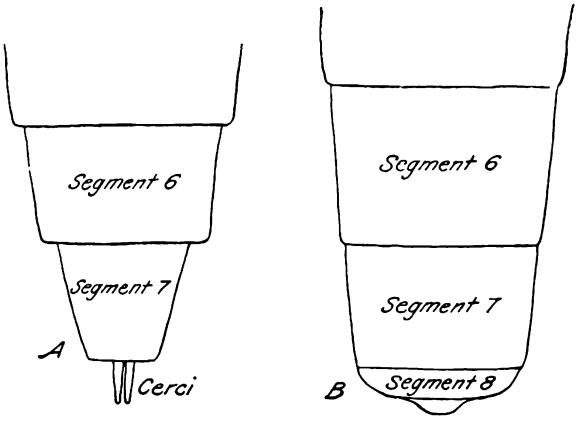
M & A 14057

FIGURE 16.—Portions of heads of various mosquito larvae: *A, Uranotaenia sapphirina; B, Deinocerites cancer; C, Toxorhynchites septentrionalis; D, Psorophora ciliata. lp,* lateral pouch; *mb,* mouth brush.

In preparing to identify a mosquito specimen, one should make a preliminary examination at a comparatively low magnification, to note the more obvious markings of the proboscis, tarsi, thorax, wings, and abdomen. With experience, the ap-

proximate position of the insect, frequently both genus and species, is recognized from this examination. There should be little difficulty in recognizing *Anopheles* and *Toxorhynchites*, and only slightly more trouble perhaps with *Uranotaenia* and *Wyeomyia*. After these genera are separated nearly all the species in which the tarsi are not ringed with white and the mesonotum is unornamented are *Culex*, *Culiseta*, or *Deinocerites*. There are three species of ringed-legged *Culex* but these are extremely rare in most of this area. In the species of the other genera, except *Psorophora cyanescens* and *Aedes cinereus*, some of the tarsal segments are ringed with white, or the mesonotum has bicolorous scaling in definite patterns of stripes, lines, or patches.

Aedes and *Psorophora* females can nearly always be distinguished from those of other genera by the tapered end of the abdomen, as shown in figure 17. This is a very useful character



M & A 14058

FIGURE 17.—Characteristic shapes of tip of female abdomen: *A*, *Aedes* (also similar in *Psorophora*); *B*, *Culex*.

although there may be some uncertainty as to the shape at times, particularly when the abdomen is distended with blood or ova, or has shriveled. *Aedes* and *Psorophora* are distinguished also from other mosquitoes, except *Mansonia titillans* and *M. indubitans*, by the presence of postspiracular bristles, but these require higher magnification than can be obtained with a hand lens in order to be seen. *Psorophora* are distinguished from *Aedes* by having spiracular bristles as well, although these bristles are frequently difficult to see even with a binocular microscope. In *Psorophora*, however, the dorsal or lateral pale scaling of the abdomen is at or toward the apex of the segments, or diffuse, whereas in *Aedes* this segmental scaling is basal, or extends from the base.

There are a few species that are so similar in appearance that they cannot be identified with certainty by adult markings, although the male terminalia may be quite distinct. In these instances, the principal distinctions of the terminalia are included in the keys, while for the dark-legged species of *Culex* a separate

key to the male terminalia has been provided. Study of the terminalia requires advanced training, and illustrations of these structures have not been included, on the assumption that anyone making use of this part of the keys would be familiar with this specialized subject.

Since few mosquitoes are known by common names, the scientific name is, as a rule, used to designate the kind under discussion.[3] During the early years of mosquito research, considerable confusion was caused by revisions of generic and specific names. Fortunately these names have now become much more stabilized and only two changes, due to the application of the rules of priority, have been made since the last edition of Miscellaneous Publication No. 336 (*193*). These are the change of genus *Megarhinus* to *Toxorhynchites* and of *Culex apicalis* to *C. territans*. Many synonyms of the names now in use have appeared in the literature but only a few of those in recent use are shown here. More complete lists may be found in Dyar (*95*), Edwards (*102*), and elsewhere.

The alphabetical listing of genera and species as given in table 1 has been followed in the notes and description.

KEY TO SUBFAMILIES AND GENERA

ADULTS

1. Palpi of both sexes about as long as the proboscis, the male palpi club-shaped (fig. 1, *A* and *D*); abdomen with a vestiture of fine hairs, at least dorsally; scutellum evenly rounded.
   Subfamily Anophelinae, genus *Anopheles* p. 85
   Female palpi much shorter than proboscis; male palpi long or short, not clubbed at tip (fig. 1, *B* and *C*); abdomen covered with flat scales 2
2. Outer half of proboscis tapered and bent downward at nearly a right angle (fig. 2, *A*); posterior border of scutellum evenly rounded and scaled. Very large iridescent species of striking appearance.
   Subfamily Toxorhynchitinae, genus *Toxorhynchites* p. 149
   Proboscis of nearly uniform thickness, straight or slightly curved; scutellum trilobed, with separated tufts of setae or scale patches (fig. 9, *B*).
   Subfamily Culicinae 3
3. Second marginal cell less than half as long as its petiole (fig. 18); very small species with lines of bluish or purplish iridescent scales on thorax and base of vein 5; palpi short in both sexes
   Uranotaenia p. 151

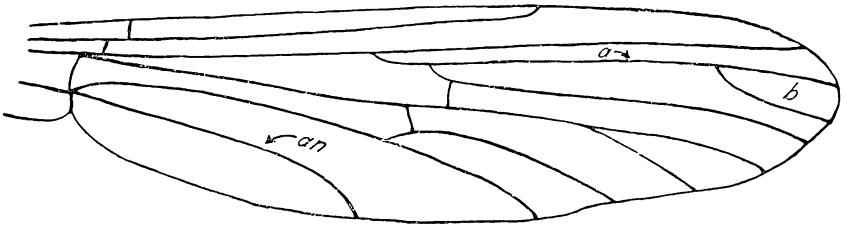
---

[3] In scientific terminology two names, the generic and the specific, are employed for each kind of organism. A genus is sometimes divided into subgenera and, when given, the subgeneric name is inserted in parentheses between the genus and species. The species may also be divided into subspecies or varieties. The name, spelled out or abbreviated, of the person who first named the species, is often added after the specific name. If the species has been changed to another genus, the name of the author is enclosed in parentheses. The designation of a species may therefore appear as *Aedes aegypti* or *Aedes* (*Stegomyia*) *aegypti* (L.), etc. When a species of mosquito shows geographically defined grouping with some taxonomic differences, but not sufficient characters to show distinct species, the differing kinds are treated as subspecies, in which case the specific name of the type (the one first described) is repeated and the others written as subspecies, e.g. *Culex pipiens pipiens* and *C. pipiens quinquefasciatus*. These two were formerly treated as distinct species but are now known to interbreed readily and to produce intermediate forms.

Second marginal cell at least as long as its petiole; iridescent scaling if present not as above; male palpi long in most genera 4

4. Thorax thickly covered with broad, closely appressed dark brown scales; abdomen somewhat compressed laterally, the scales entirely dark dorsally and white ventrally, the two colors meeting to form an almost straight line along the middle of the sides; postnotum with a tuft of setae. Very small species *Wyeomyia* p. 153

Thorax not completely covered with broad dark scales (some species of *Psorophora* partly covered with broad whitish scales); abdomen not as above, usually flattened dorsoventrally, or if rounded or distended, the colors not forming a straight line; postnotum bare 5



M & A 14059

FIGURE 18.—Wing of *Uranotaenia*, showing relation of length of the second marginal cell (*b*) to its petiole (*a*); also the short anal vein (*an*).

5. Tip of abdomen with a tapered appearance (fig. 17, *A*), segment 7 much narrower than segment 6, segment 8 still narrower and completely retractile, the cerci long and exserted; postspiracular bristles present 6

Tip of abdomen truncate or bluntly rounded (fig. 17, *B*), segment 7 not markedly narrowed, segment 8 not retractile but frequently quite short, the cerci usually retracted or only indistinctly visible; postspiracular bristles absent (except in *Mansonia titillans* and *M. indubitans*) 7

6. Dorsal or lateral white scaling of abdominal tergites apical or the segments almost entirely pale-scaled; spiracular bristles present; mesonotum with at least some broad appressed scales (except in subgenus *Grabhamia*) ..... *Psorophora* p. 137

Dorsal or lateral pale scaling of abdominal tergites basal, sometimes with a median stripe extending to apex of the segments; spiracular bristles absent; scales of mesonotum narrow or lanceolate ..... *Aedes* p. 59

7. Wing scales very broad, mixed brown and white; setae absent at base of vein 1; proboscis and legs speckled with white scales and tarsi ringed with white 8

Wing scales long and slender on veins 2 to 4, or if moderately broadened, not mixed brown and white; a few setae present on base of vein 1 on upper side of wing in *Culex* and *Deinocerites*, proboscis and legs not speckled and tarsi not ringed in the majority of species 9

8. Mesonotum with fine longitudinal lines of white scales (fig. 19, *I*) tarsal segments with both apical and basal white rings; segment 4 of fore tarsi very short, about as long as wide *Orthopodomyia* p. 134

Mesonotum without such lines; tarsal segments not ringed apically; segment 4 of fore tarsi normal, considerably longer than wide *Mansonia* p. 127

9. Antenna much longer than proboscis, the first flagellar segment as long as several of the succeeding segments; sternopleuron almost completely shingled with dark appressed scales; male palpi and antennae similar to those of female. The crabhole mosquito, found in coastal areas of southern Florida ..... *Deinocerites* p. 126

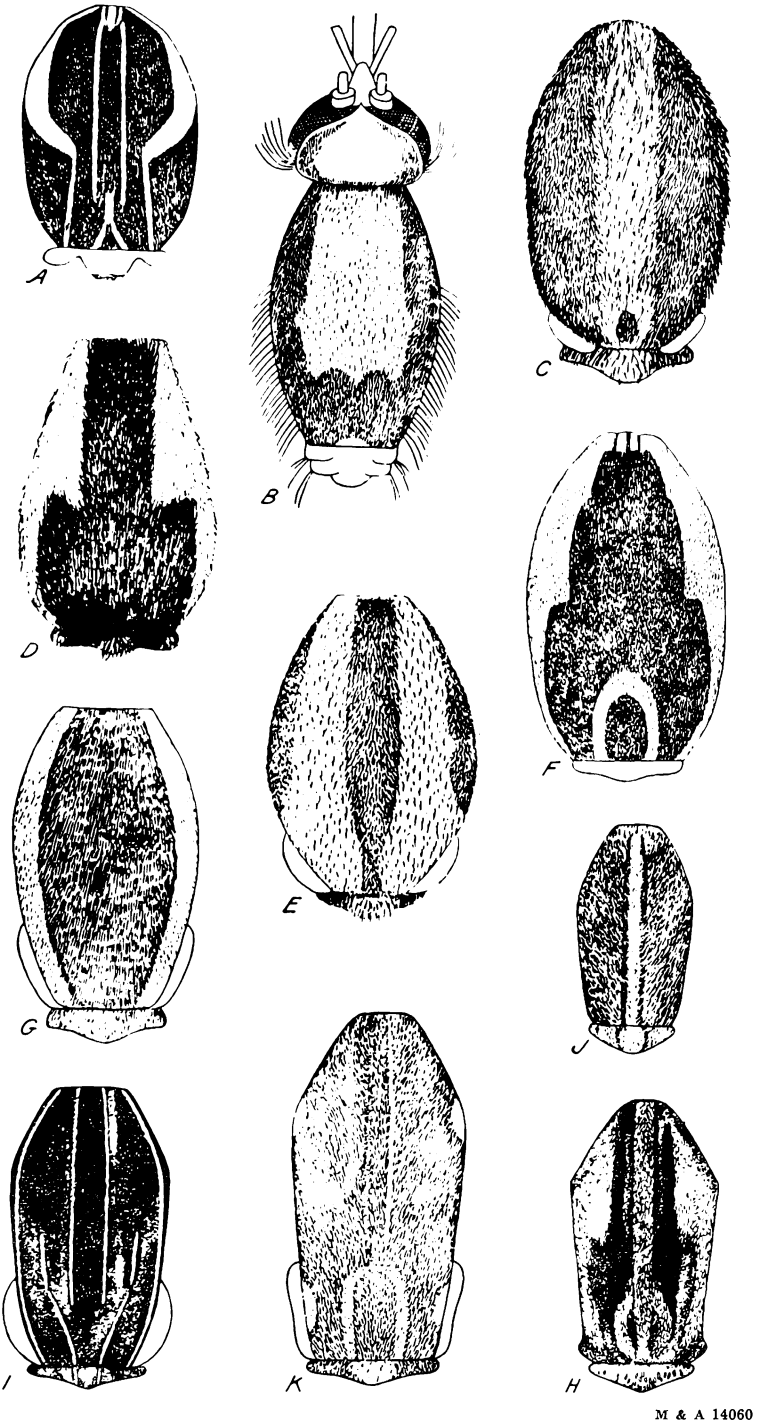


FIGURE 19.—Examples of thoracic markings of mosquitoes (diagrammatic): *A, Aedes aegypti; B, A. infirmatus; C, A. atlanticus; D, A. thibaulti; E, A. trivittatus; F, A. triseriatus; G. Psorophora varipes; H, P. ciliata* (at a scale one-half the size of the others); *I, Orthopodomyia signifera; J, Uranotaenia sapphirina; K, Culex restuans.*

Antenna normal, not longer than proboscis, the first flagellar segment about the same length as succeeding ones; sternopleuron not shingled with dark scales; male palpi long, the antennae plumose 10

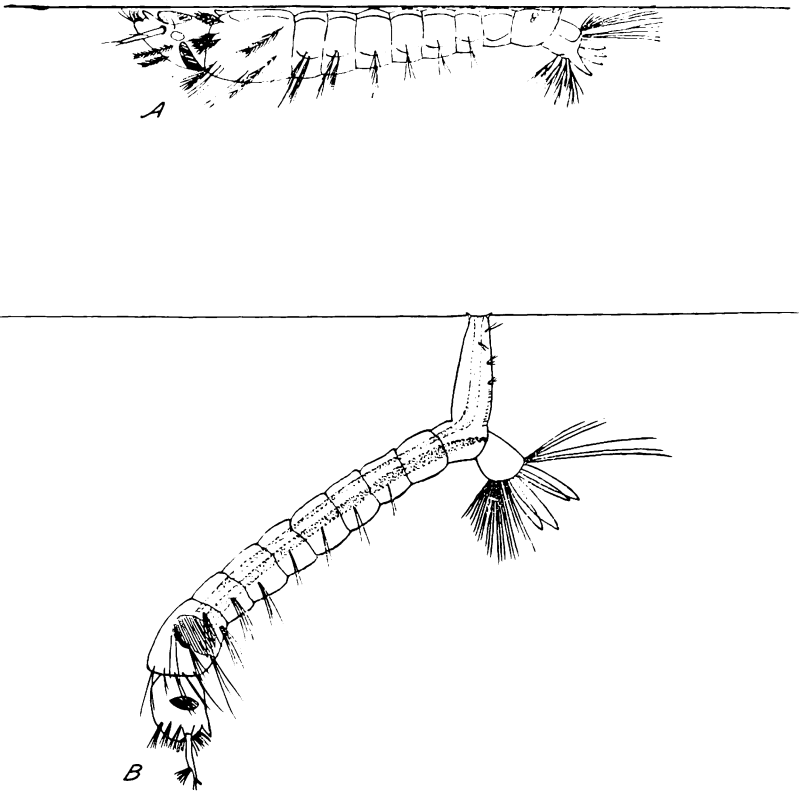
10. Spiracular bristles absent; base of subcostal vein without a tuft of setae on underside of wing ..... *Culex* p. 103

Spiracular bristles present; base of subcostal vein with a row or tuft of setae on underside of wing. (If it is uncertain to which of these two genera the specimen belongs, it should be run under genus *Culex* where a notation is inserted in the proper place for separating each of the two species of *Culiseta*) .... *Culiseta* p. 124

LARVAE (FOURTH INSTAR)

1. Air tube lacking (spiracles on 8th abdominal segment sessile) (fig. 20, *A*); some of abdominal segments with palmate hairs (fig. 13, *B*) ..... Subfamily Anophelinae, genus *Anopheles* p. 85

Eighth abdominal segment with an elongate air tube (figs. 20, *B*, and 11); abdomen without palmate hairs 2



M & A 12938

FIGURE 20.—Feeding positions of mosquito larvae: *A*, *Anopheles*; *B*, *Culex*.

2. Mouth brushes each consisting of about 10 stout, closely appressed, prehensile, curved rods, without a row of comblike teeth on one side; 8th segment without comb scales but with a sclerotized plate having two spinulose bristles on posterior border; pecten lacking. Very large predacious larvae found in tree holes Subfamily Toxorhynchitinae, genus *Toxorhynchites* p. 149

Mouth brushes ciliform, the hairs numerous, or if with stout prehensile hairs (subgenus *Psorophora*) each hair with a row of comblike teeth along the side; comb scales present on 8th segment, sometimes (genus *Uranotaenia*) attached to a sclerotized plate ..... Subfamily Culicinae 3

3. Distal half of air tube attenuated (fig. 14, *B*), with saw-toothed projections at tip adapted for piercing the roots of aquatic plants; pecten lacking ..... *Mansonia* p. 127

Air tube cylindrical, or spindle-shaped; the distal half not attenuated 4

4. Air tube without a pecten 5

Air tube with a pecten 6

5. Comb scales in a single row; anal segment with a pair of ventro-lateral hair tufts (fig. 15, *C*) instead of the usual median ventral brush ..... *Wyeomyia* p. 153

Comb with one row of short scales and a second row of very long, pointed scales; anal segment with the usual median ventral brush consisting of a close-set row of tufts ..... *Orthopodomyia* p. 134

6. Head longer than wide, elliptical; upper and lower head hairs single, stout, spinelike (fig. 16, *A*); eighth abdominal segment with a large lateral plate having a row of tooth-like scales on the posterior border ..... *Uranotaenia* p. 151

Head wider than long; head hairs, slender, frequently multiple; eighth segment not as above (small weak plates usually present in subgenus *Grabhamia*) 7

7. Head with a prominent triangular pouch on each side (fig. 16, *B*); anal segment with a small sclerotized plate dorsally and ventrally; only two small bulbous anal gills. Found in crab holes along the coast of southern Florida ..... *Deinocerites* p. 126

Head without lateral pouches; anal segment completely ringed by the plate or with only a dorsal saddle; four anal gills 8

8. Air tube with a single pair of ventro-lateral hair tufts, more or less centrally placed (sometimes very small or obsolete in *Psorophora*) 9

Air tube with several pairs of ventro-lateral hair tufts or single hairs beyond the pecten, or a ventral row of numerous small tufts 10

9. Anal segment completely ringed by sclerotic plate and the plate pierced on mid-ventral line by tufts of the ventral brush (fig. 14, *A*) ..... *Psorophora* p. 137

Anal segment not completely ringed by plate, or if ringed, tufts forming ventral brush are all posterior to plate (fig. 15, *A* and *B*) ..... *Aedes* p. 59

10. Air tube with four or more pairs of hair tufts or single hairs beyond the pecten, none at base ..... *Culex* p. 103

Air tube with a pair of multiple hair tufts near base with a paired row of single hairs beyond the pecten (fig. 14, *C*), or a ventral row of numerous small tufts ..... *Culiseta* p. 124

Genus AEDES Meigen

This is a very large genus and all the species probably are biters. Some of them are of great economic importance both as pests and as vectors of diseases. The eggs of most species are laid on damp soil in places that become filled periodically with rainwater, tides, stream overflows, melting snow, et cetera. There are a few species with specialized breeding places such as rock holes, tree holes, and artificial water containers. The eggs are usually laid on the sides of the container just above the water line. In general, the eggs can withstand long periods of drying, and the winter is passed in this stage. Many species have only a single annual generation but there may be several broods from the overwintered eggs when only a partial hatch occurs with each flooding. With other species the eggs can hatch the same season

in which they are laid, and several generations are produced if alternate drying and flooding of the breeding places occurs.

When large areas such as salt marshes, pastures, and river flood plains, heavily seeded with eggs, are flooded, enormous broods may be produced, resulting in a serious infestation of large areas since some of these species commonly disperse for many miles.

The majority of species in this genus are ornamented with white scales, many having the tarsi ringed with white, some with the proboscis also ringed, and others with stripes or patches of white or yellowish scales on the thorax. Only one of the species, *A. cinereus,* lacks both tarsal and mesonotal markings. Spiracular bristles are absent in the genus but postspiracular bristles are present. Lower mesepimeral bristles are present in some species, absent in others. The posterior border of the scutellum is partly divided by indentation into three distinct lobes.

In the females of this genus abdominal segments 6 and 7 are distinctly narrowed, segment 8 is small, usually completely retracted into segment 7, and the slender cerci protrude from the tip of the abdomen (fig. 17). This gives the abdomen a pointed appearance, in comparison with the blunt shape of other mosquitoes, and is characteristic of *Aedes* and *Psorophora* females —usually sufficient by itself to identify these two genera with the naked eye or a hand lens.

In the larvae the air tube is usually short and stout and has a single pair of ventral hair tufts, usually fairly long and multiple, placed near the middle of the tube or slightly beyond. The distal teeth of the pecten may be either evenly or unevenly spaced and may extend beyond the tuft. The comb on the eighth segment is either in the form of a patch or a single row. The anal segment may or may not be completely ringed by the sclerotic plate, and the upper and lower head hairs may be single or multiple. These characters are all used in classification. The pupae are of normal appearance with fairly short air tubes. The eggs are somewhat spindle-shaped, and the surface has a fine, hexagonal reticulation (fig. 3, *B*).

Nineteen of the 24 species of *Aedes* included here are placed in the subgenus *Ochlerotatus.* The other five are divided as follows: (*Aedes*) *cinereus;* (*Stegomyia*) *aegypti;* (*Aedimorphus*) *vexans;* (*Finlaya*) *triseriatus,* and (*Finlaya*) *atropalpus.*

The separation of the subgenera is based principally on the male terminalia and palpi. There are few or no characters in the females or larvae that can be used satisfactorily. For this reason not much use is made of the subgeneric divisions in practical mosquito work—at least for the species in our area. The main subgeneric distinctions are:

1. Male palpi very short ..... *Aedes*
   Male palpi about as long as proboscis 2
2. Terminal claw of dististyle inserted well before tip; claspette without an apical filament ..... *Aedimorphus*
   Terminal claw of dististyle inserted at tip; claspette, if present, with a filament 3
3. Claspette lacking 4
   Claspette present ..... *Stegomyia*
4. Basistyle with a weakly developed basal lobe and without an apical lobe ..... *Finlaya*
   Basistyle with a well-developed basal lobe and usually an apical lobe ..... *Ochlerotatus*

KEY TO SPECIES

ADULTS

1. Some of tarsal segments ringed with white or yellowish scales 2
   Tarsal segments not ringed with white 13
2. Proboscis with a white ring near middle 3
   Proboscis not white-ringed (nearly all yellowish in *A. fulvus pallens*) 5
3. Abdomen with basal transverse white bands but without a longitudinal stripe; dark portions of femora and tibiae not speckled with white; mesonotum with dark brownish scales, sprinkled with silver posteriorly ..... *taeniorhynchus*
   Abdomen with a dorsal longitudinal stripe of white or yellowish scales (fig. 8) in addition to transverse basal stripes; femora and tibiae speckled with white; mesonotal scales golden 4
4. Wing scales brown and white mixed; first hind tarsal segment with a pale ring in middle. Important salt-marsh species ..... *sollicitans*
   Wing scales entirely dark; first hind tarsal segment without a central pale ring. A fresh-water breeder, usually rare ..... *mitchellae*
5. Mesonotum bright yellow, with two shiny black spots on posterior corners; proboscis, wing costa, and legs largely yellowish-scaled. Usually rare ..... *fulvus pallens*
   Not so marked 6
6. Mesonotum with four silvery lines, the outer pair curved to form a lyre-shaped marking (fig. 19, *A*). The yellow fever mosquito ..... *aegypti*
   Mesonotum without such lines (indefinite curved lines sometimes present in *canadensis*) 7
7. Tarsal segments ringed only basally; fifth hind tarsus not all white 8
   Tarsal segments ringed basally and apically; fifth hind tarsus all white (except in *canadensis mathesoni*) 10
8. Wing scales all dark, narrow; white rings on tarsi narrow, no wider than the diameter of segment; basal abdominal pale bands with an inverted V-shaped notch in the posterior margin on apical segments ..... *vexans*
   Wings with brown and white scales intermixed; tarsal white rings wider than diameter of segment, at least on hind feet, abdominal bands not notched 9
9. Thorax with white lateral patches on anterior half; wing scales very broad ..... *grossbecki*
   Thorax without white lateral patches; wing scales narrow. Recorded only once from Mississippi ..... *stimulans*
10. (7)[4] Abdominal tergites almost entirely pale-scaled except for dark, quadrate, submedian spots; wing scales mixed black and white ..... *dorsalis*
    Abdominal tergites with only the usual white basal bands or lateral spots; wing scales all dark 11
11. Mesonotum pale, with a well defined, median dark stripe. Breeds in rock holes ..... *atropalpus*
    Mesonotum golden or dark brown, without a median dark stripe 12
12. Mesonotal scales golden brown, with some pale scales often forming faint or indefinite lines or stripes; last hind tarsal segment all white; segments 1 to 4 with fairly broad basal and apical white rings ..... *canadensis canadensis*
    Mesonotal scales mostly dark brown, with indefinite stripes of pale scales; last two hind tarsal segments typically entirely dark, segments 1 and 2 with narrow basal and apical rings, segment 3 ringed basally only; intergrade specimens with the last hind tarsal segment entirely or partially white, or white on one side ..... *canadensis mathesoni*
13. (1) Abdominal segments with dorsal white bands or median triangular spots 14
    Abdominal segments with only lateral white spots 17

[4] Couplet 7 is the one from which couplet 10 leads. Similar numbers are given throughout the keys for convenient reference when there is a skip of more than one couplet.

14. Abdomen with large median triangular white patches at the base of the tergites; mesonotum covered entirely with yellowish scales, or with a median longitudinal stripe of somewhat darker scales. Florida Keys ..... *thelcter*
Abdominal segments with basal white bands; mesonotum not as above 15
15. Mesonotum uniformly dark-scaled ..... *cinereus*
Mesonotum with bicolorous markings, (sometimes indistinct in *tortilis*) 16
16. Mesonotum with a broad median stripe of yellowish or brownish scales and silvery scales laterally; dark portions of femora speckled with white ..... *sticticus*
Mesonotum with golden scales divided by a pair of narrow submedian longitudinal stripes, and with narrow dark stripes laterally; dark portions of femora not speckled with white. South Florida ..... *tortilis*
17. (13) Mesonotum with a median longitudinal stripe or patch of silvery scales 18
Mesonotum with a median dark stripe and silvery scales laterally 22
18. A broad median patch ending just back of middle of mesonotum, the silvery area wider than the dark area on each side (fig. 19, *B*) 19
Median stripe extending full length of mesonotum, usually narrower (somewhat variable in *A. dupreei*) than the dark lateral areas (fig. 19, *C*) 20
19. Two species difficult to distinguish as adults except by slight differences in male characters.
Male terminalia:
Claspette with a flattened apical filament having one long and several small backward-pointing spines on the inner margin. Fairly common species in the Southeast. .... *infirmatus*
Claspette filament with only one retrorse spine. Taken once on the Florida Keys ..... *scapularis*
20. Occiput with a narrow median line of pale lanceolate scales, bordered by broad white and dark scales; small species (wing about 2.5 mm.); mesonotum of male with a very broad stripe or entirely silvery scaled; male claspette with a slender stem and filament, the latter slightly longer than the stem, smoothly tapered to a sharp point ..... *dupreei*
Occiput with a wide median area of pale, lanceolate scales, bordered by broad, appressed, mostly dark scales; medium-sized species (wing about 3.5 mm.); male not as above 21
21. Two species difficult to distinguish except by male characters.
Male terminalia:
Stem of claspette long, greatly enlarged in middle, and densely hirsute; filament very short, stout ..... *atlanticus*
Stem of claspette long and slender, slightly pilose on basal half; filament about one-third length of stem, with a pointed, slightly hooked tip ..... *tormentor*
22. (17) Mesonotum with a pair of broad submedian stripes of yellowish-white scales; dark centrally and laterally (fig. 19, *E*) .. *trivittatus*
Mesonotum with a prominent patch or stripe of pale scales on each side, dark centrally 23
23. Posterior pronotum densely covered with broad, appressed, white scales; mesonotum with silvery-white scales along sides, the median area broadly dark-scaled (fig. 19, *F*). A common woodland species, breeding in tree holes ..... *triseriatus*
Posterior pronotum with lanceolate scales, not closely appressed, mesonotum with broad lateral patches of yellowish-white scales anteriorly, reduced to narrow stripes posteriorly by an abrupt widening of the median dark-scaled area (fig. 19, *D*). Breeds in stump holes, usually rare ..... *thibaulti*

LARVAE (FOURTH INSTAR)

1. Upper head hair multiple, lower hair double or multiple (fig. 12); anal segment not completely ringed by the sclerotized plate 2

Either the upper or lower head hairs single (both pairs single unless stated otherwise); anal segment with the plate complete or incomplete 7

2. Pecten with one or more distal teeth more widely spaced than the others (fig. 15, *A*); comb of few scales in a single irregular or partially double row 3

Pecten with evenly spaced teeth; comb scales in a triangular patch 4

3. Upper head hair with three to five branches, lower usually with two or three; lateral abdominal hairs double or triple on segments 3 to 5 ..... *vexans*

Upper and lower head hairs with more than four branches; lateral abdominal hair single on segments 3 to 5 ..... *cinereus*

4. Lower head hair double 5

Lower head hair with three or more branches 6

5. Comb scales with a long apical spine, thornlike ..... *sticticus*

Comb scales rounded, fringed with subequal spinules ..... *grossbecki*

6. Upper lateral hairs or both pairs on abdominal segments 1 and 2 multiple; antenna nearly as long as head; comb scales with the apical and preapical spines strong, the others progressively smaller ..... *thibaulti*

Upper lateral hairs on segments 1 and 2 double, the lower single or double; antenna much shorter than head; comb scales fringed apically with subequal spinules ..... *canadensis canadensis canadensis mathesoni*

7. (1) Anal segment not completely ringed by the sclerotic plate 8

Anal segment completely ringed by the plate 12

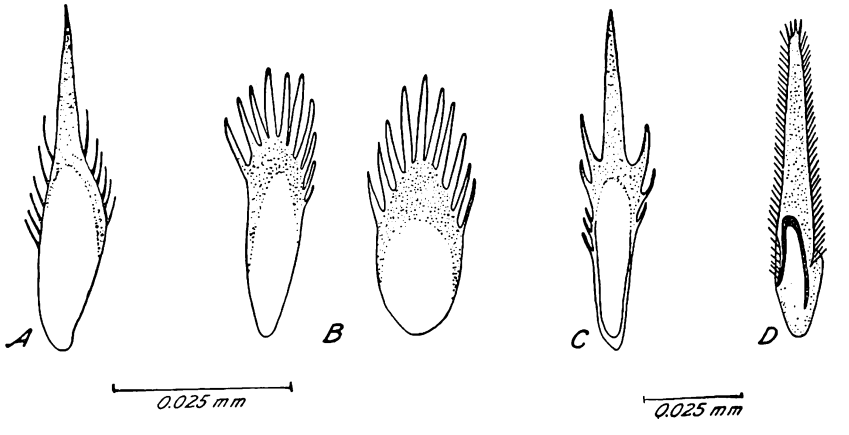
8. Pecten with the distal teeth unevenly spaced ..... *atropalpus*

Pecten with evenly spaced teeth 9

9. Antennal hair single (rarely forked); comb of few (8 to 15) scales in a single or partly double row 10

Antennal hair multiple; comb of many scales in a patch 11

10. Comb scales with a long apical spine and a few much shorter side spines (fig. 21, *C*) head hairs and preantennal hair single; tuft of air tube with three or more branches ..... *aegypti*



M & A 14061

FIGURE 21.—Enlarged comb scales of *Aedes* larvae: *A, sollicitans; B, taeniorhynchus; C, aegypti; D, triseriatus.*

Comb scales elongate, evenly fringed with numerous fine spinules (fig. 21, *D*); upper hair single, lower with two to four branches, preantennal hair multiple; tuft of air tube single or double *triseriatus*

11. Upper head hair double; anal gills as long as the segment; comb scales with a long apical spine twice as long as the subapical pair ..... *stimulans*

Both head hairs usually single; gills very short; comb scales rounded, fringed apically with subequal spinules ..... *dorsalis*

12. (7) Pecten with one or more distal teeth more widely spaced and extending on air tube beyond the ventral hair tuft 13

Pecten with evenly spaced teeth, none beyond the ventral tuft (except in *A. tormentor*) 14

13. Comb scales in a patch, each scale rounded and fringed with subequal spinules; lower head hair double or triple ..... *fulvus pallens*

Comb scales in a single irregular row, the scales with the apical spine much longer and stouter than the others ..... *thelcter*

14. Comb of few scales (less than 12) in a single row, the scales pointed, thornlike 15

Comb of many scales in two or three rows, the scales thornlike, or rounded and fringed 17

15. Anal gills as long as entire body, with prominent tracheae; lower head hair double or triple ..... *dupreei*

Anal gills much shorter than body; lower head hair single 16

16. Airtube with the ventral brush inserted before end of pecten; anal gills all of equal length ..... *tormentor*

Ventral brush of air tube beyond pecten; one pair of anal gills longer than the other ..... *atlanticus*

17. (14) Comb scales rounded apically and fringed with subequal spinules, or the apical spine less than twice as long as the adjacent ones; body pilose 18

Comb scales thorn-shaped, or with the apical spine much longer and stouter than the others; body glabrous (except in *A. infirmatus*) 21

18. Anal gills shorter than anal segment, budlike (but may be longer when the larvae develop in fresh water); body sparsely pilose *taeniorhynchus*

Anal gills longer than segment 19

19. Body densely pilose, or spiculate; gills about twice as long as anal segment and about equal in length to the ventral brush. Florida Keys ..... *scapularis*

Body sparsely pilose; anal gills otherwise 20

20. Anal gills less than twice as long as segment and shorter than the long hairs of ventral brush; comb scales fringed with fairly small spinules, the apical one slightly longer than others; air tube 2.5-3:1. Southern Florida ..... *tortilis*

Anal gills two to three times as long as segment, longer than hairs in ventral brush; apical spine of comb scales stout, fairly long, the preapical pair about two-thirds as long; air tube about 2:1. Rare in southeast, not reported in Florida ..... *trivittatus*

21. (17) Anal gills shorter than segment, budlike; air tube about 2:1 *sollicitans*

Anal gills longer than segment; air tube 2.5-3:1 22

22. Body glabrous; dorsal preapical spines of air tube (fig. 15, *A*) longer than apical pecten tooth ..... *mitchellae*

Body sparsely pilose; preapical spines of air tube not more than half as long as apical pecten tooth ..... *infirmatus*

AEDES AEGYPTI (L.)

(Syn., *Stegomyia fasciatus* F., *Culex calopus* Meig., C. *argenteus* Poir., etc. The yellow fever mosquito.)

A rather small, dark mosquito with conspicuous rings on the hind tarsi and a lyre-shaped pattern of silvery white scales on the thorax (fig. 19, *A*).

This species is the most thoroughly domesticated of any of the mosquitoes and apparently greatly prefers the blood of man to that of other animals. It breeds almost exclusively in artificial water containers in the vicinity of dwellings or in the dwellings themselves. The larvae are found occasionally in tree holes and similar natural collections of water, but, so far as known, never

in ground pools except under unusual circumstances. In Orlando, Fla., the writers found the larvae abundant at times in the underground street catch basins, which, although partly filled with sand and dirt, were lined with brick or concrete. Fairly clean water is preferred, and sewage-polluted water in wooden or concrete cesspools is not a favorable breeding medium. The larvae mature in from six to ten days under favorable conditions in the summer, but development is prolonged in cooler weather.

The eggs are usually laid on the sides of the receptacle just above the water, but may be deposited directly on the water surface. It appears that places having solid material at the water line are preferred, although in the laboratory they oviposit readily on moist filter paper. The embryos mature in from two to four days, depending on the temperature, after which hatching may take place when suitable conditions occur. The eggs may be kept dry and will remain dormant for several months, yet hatch quickly when flooded. Under favorable summertime conditions the complete cycle from egg to adult may be completed in ten days.

The adults are abundant during the summer in cities and towns throughout the South and are troublesome house pests. Biting occurs largely in the daylight hours, especially early in the morning and late in the afternoon, and the females seem able to gain entrance even into well-screened houses. They are wary biters and are especially annoying about the ankles. *Aedes aegypti* is thought to have been the only species involved in the epidemics of yellow and dengue fevers in the United States, although other species in other countries have been proved capable of transmitting both these diseases. Experimentally, *A. aegypti* is able to transmit the viruses of the three most important strains of encephalitis found in the United States. It has been found capable of transmitting the virus of fowl pox, and is an efficient host for several of the species of *Plasmodium* infecting birds.

The adults have been kept alive in the laboratory for several months, and in the summer they probably live longer than any other of the southern species. They are very susceptible to cold, however, and are said to die at temperatures below about 40° F. Although the eggs are more resistant, the species probably does not overwinter in the United States except in the extreme southern part where breeding may be continuous throughout the year. Each summer it becomes widely dispersed into territory farther north, probably transported in trains, boats, et cetera. The adults are strong fliers but the usual flight range is considered to be not more than a few hundred feet.

The control of this species is discussed in the section on mosquito control.

ADULT.—Tips of female palpi white, and clypeus covered with broad white scales. Occiput with a narrow median and lateral stripes of white separated by broad patches of dark scales. Mesonotum with a pair of fine submedian lines of silvery white scales extending back of middle, broader lateral lines curved around the fossae and continued to posterior end of scutum forming a lyre-shaped pattern; prescutellar space with a border of white scales. Lobes of the scutellum white-scaled, and patches of white on sides of thorax. Abdominal segments with narrow basal white bands and long lateral spots. Wing length about 3 mm., the scales all dark. Front and mid tarsi with

narrow white basal rings on segments 1 and 2 only; hind tarsi with wide basal rings on segments 1 to 3, segment 4 nearly all white except for a narrow black ring at tip, segment 5 all white.

LARVA.—Antennal hair single, minute; upper and lower head hairs and preantennal hair each single, long. Comb scales in a single, curved row, each with a long, central spine and several much shorter lateral spines (fig. 21, *C*).

Air tube about 2:1 with a ventral tuft of two or more branches, usually three. Anal segment not completely ringed by the plate, the gills about twice as long as the segment, the tips bluntly rounded.

AEDES ATLANTICUS D. and K.

(Syn., *Ochlerotatus serratus* Coq. (not Theob.), in part)

This mosquito is recognized by the broad median white stripe extending the full length of the thorax (fig. 19, *C*). The tarsi are unbanded. It breeds in temporary rain pools. The writers have taken the larvae in some numbers in Louisiana and Florida in shaded woodland pools, associated with other woodland species. In southern Mississippi they were taken in clear grassy pools (*225*). On Long Key, Monroe County, Fla., their breeding place was a shallow pool in marl soil filled with a thick growth of purslane (*Sesuvium*) associated with larvae of *Aedes thelcter* and other species of *Aedes* and *Psorophora* (*305*). The female is a severe daytime biter in and near woods, and is usually associated with *A. infirmatus* and other woods species.

This mosquito is common in the Southeastern States and has been recorded in all except Tennessee, where it probably will be found also. Its range extends from Texas to Missouri and eastward to New York.

ADULT.—Proboscis, wings, and tarsi all dark-scaled. Occiput with a large median area of pale lanceolate scales bordered by broad flat scales, mostly dark. Mesonotum with a broad median stripe of silvery white scales extending the full length of the scutum, narrower than the dark area on each side (fig. 19, *C*). Lower mesepimeral bristles absent. Wing length about 3.5 to 4 mm. Abdominal segments unbanded, with basal white lateral spots visible from above on the posterior segments. Stem of male claspette long, greatly enlarged in middle, and densely hirsute; filament stout, much shorter than stem, the stem without a bristle. The female is indistinguishable from *A. tormentor*, and is also very similar to *A. dupreei* except for its larger size and slight difference in the scaling of the occiput and first hind tarsal segment. The male claspette is distinctive.

LARVA.—Antennal and preantennal hair multiple; upper and lower head hairs both single, sparsely spiculate. Body glabrous, lateral abdominal hair single on segments 3 to 5; comb of only 5 or 6 scales in a single row, each scale thorn-shaped and finely fringed laterally. Air tube about 2:1, the pecten with evenly spaced teeth, the ventral tuft multiple, inserted beyond pecten. Anal segment completely ringed by the plate, the lateral hair single; gills with the upper pair longer than the lower, pointed, about three times as long as the segment.

AEDES ATROPALPUS (Coq.)

This rare, medium-sized species has white scales laterally on the mesonotum and a broad median stripe of dark scales, in this respect somewhat resembling *Aedes triseriatus*. The tarsal segments are ringed at base and apex. It breeds normally in rock holes along mountainous stream beds, sometimes in rocks away from the streams. Larvae were collected from pot holes in an unfinished concrete foundation of a power dam in Georgia (*299*). In Texas, they were taken in two tree holes in hackberry trees,

and once in an artificial water container (*146*). In the rock holes this author found that the eggs might be laid on the water surface during the summer, but were always laid on the sides of the rock holes by the last generation in the fall. Larvae of *Culex tarsalis* frequently were associated with *atropalpus*, and with numerous other species occasionally. The adults are said to be annoying but remain near their breeding places, and since these are of very local and scattered distribution, the species is considered to be of little importance. A blood meal is not required for egg production. *Atropalpus* was previously reported (*193*) from Arkansas, Tennessee, and North Carolina. There are additional State records from Baldwin and Rabun Counties, Georgia (*299*), and Oconee County, South Carolina (*65*). It is widely, but locally, distributed throughout the Eastern and Midwestern States to Minnesota, Texas, and New Mexico.

ADULT.—Proboscis dark. Occiput with a median patch of narrow whitish scales, broad white ones laterally enclosing a patch of dark scales. Mesonotum with lateral patches of yellowish-white scales anteriorly, separated by a broad median dark stripe which widens to almost the complete width of scutum back of the fossae; prescutellar space surrounded by pale scales. Lobes of scutellum with narrow, pale scales. Lower mesepimeral bristles absent. Wing length about 3.5 mm., the scales dark except for a short line of white at base of costa. Hind tarsi with basal and apical white rings on segments 1 to 4, segment 5 entirely white; fore and mid tarsi with narrower rings on the first three segments, segments 4 and 5 and tip of 3 usually all dark. Abdomen with broad basal, segmental white bands.

LARVA.—Antennal tuft double or triple; upper and lower head hairs single. Body glabrous. Lateral abdominal hairs multiple on segments 3 to 5; comb scales in a patch, each narrowly rounded and fringed with subequal spinules. Air tube 2:1, the tuft large and multiple, the pecten with two or three of the apical teeth more widely spaced than the others and extending beyond the tuft. Anal segment with a small plate covering only about half the segment, the lateral hair single, not inserted in plate. Gills more than twice the length of segment, bluntly pointed.

AEDES CANADENSIS CANADENSIS (Theob.)

The thorax of this species is golden-brown, usually with indistinct lines of white scales. The tarsal segments have fairly broad apical and basal rings. The larvae develop principally in woodland pools, and in Tennessee were found to prefer small, shaded pools with a bottom of dead leaves (*287*). They are also found in roadside puddles, spring-fed pools, cranberry bogs, pools in open sphagnum bogs, wooded swamps and open meadows (*213*). In Tennessee the larvae were associated chiefly with *Aedes vexans* (*290*). In southern Mississippi they were sometimes exceedingly abundant in water pits, often associated with *Culex restuans* and *C. apicalis* (= *C. territans*); also found in small deep puddles along intermittent streams and in receding river flood waters associated with *Aedes sticticus*, *A. vexans*, and *Psorophora ferox* (*225*). The over-wintered eggs hatch in the early spring and there seems to be only one generation a year, although larvae are sometimes found in small broods during the summer, presumably from delayed hatchings. The adults are sometimes numerous and attack readily but do not disperse far from their breeding places. This species has been recorded from all the Southeastern States (*193*). It is widely distributed in the United States, except the extreme Southwest, and occurs in Canada.

ADULT.—Proboscis dark. Occiput with a median area of narrow white scales, submedian areas of darker narrow scales and lateral patches of broad white scales. Mesonotal scales mostly brownish or golden-brown, paler around antiscutellar space and anterior lateral margins, often with faint submedian lines on posterior half or with indistinct curved lines around fossae. Lobes of scutellum with narrow pale scales. Lower mesepimeral bristles absent. Wing length about 3.5 mm., dark scaled. Hind tarsi with basal and apical white rings on segments 1 to 4, segment 5 all white; front and mid tarsi with narrower apical and basal rings on segments 1 to 3, sometimes on 4. Abdomen with basal segmental white bands joined to the lateral spots, sometimes reduced in width or lacking on some segments.

LARVA.—Antenna about half the length of head. Antennal and preantennal tufts multiple; upper head hair with 4-10 branches, the lower with 4-8. Body glabrous. Upper lateral hairs on abdominal segments 1 and 2 double, the lower single or double; lateral hair on segments 3 to 5 usually double. Comb of segment 8 a large patch of scales, each rounded and fringed with subequal spinules. Air tube about 3.5:1, the ventral tuft multiple, inserted beyond pecten. Anal segment not completely ringed by plate, the lateral hair single, gills pointed, as long as segment or longer.

AEDES CANADENSIS MATHESONI Middlekauff

This species differs from the type form in its generally darker color and a reduction of white on the tarsi. It was described by Middlekauff (*226*) as a new species from Florida. The holotype was a female from Kissimmee, with paratypes from McDill Field, Pinecastle, and Camp Murphy. The larva was described by Rings and Hill (*265*) from specimens collected in deep fox holes at Camp Blanding, Starke, Fla., and Camp Gordon, Augusta, Ga. These fox holes were shaded by overhanging grass and contained water about 8 inches deep. Further taxonomic study by these authors (*266*) led them to assign it to a subspecific status as a "melanistic, geographical variation" of *canadensis*. Its present known distribution is entirely southern, and they point out that, of the climatic factors that may influence geographical variations, the most important one affecting pigmentation is considered to be temperature. Besides northern Florida and Georgia, a distribution map in the 1948 article shows its occurrence in Alabama and South Carolina.

ADULT.—Mesonotal scales mostly dark brown, with a median fine line of very small golden brown scales; an elongate stripe of yellowish-white scales on the anterior angles and similar patches laterally at middle, sometimes with faint or indefinite curved lines around the fossae; prescutellar space with a few yellowish-white scales. Wings and legs with purplish scales. Hind tarsi typically with narrow white rings at base and apex of segments 1 and 2, and base of 3, the rest of the segments entirely dark. Abdomen purplish black without segmental bands but with small triangular lateral white spots. In the type form, the white areas on the tarsi are more extensive and the fifth hind tarsal may be partially or entirely white. The mesonotum lacks the black scales, frequently has fairly distinct curved submedian pale lines, and the abdomen frequently is banded with white. Rings and Hill (*266*) have illustrated some of these intergradations. The male terminalia of the two subspecies are indistinguishable.

LARVA.—The larvae of the two forms are also very similar except for slight differences in the number of branches of the upper and lower head hairs. In *mathesoni*, branches of the upper hair range in number from 6 to 14 with an average of 9.8, compared with a range of 4 to 10 and an average of 6.8 in *canadensis*.

AEDES CINEREUS Meig.

(Syn., *A. fuscus* O. S., etc.)

Except for broad white bands on the abdomen this species is

unornamented. It is the only representative in the United States of subgenus *Aedes,* in which the male palpi are very short. Larvae were collected in Mississippi in floodwater pools in the early spring, associated with *A. vexans* (*245*). Thibault (*303*) reported that the adults were numerous in weeds and grass and about dwellings near Scott, Ark., but did not bite. These seem to be the only published bits of information on the habits of *cinereus* in the Southeast. Other records of its occurrence in this area are from light-trap collections. In the northern and western States it breeds in woodland pools and a variety of other habitats in association with numerous other species. It hibernates in the egg stage and is thought to have a single annual generation. The female is said to be a pest in some places.

This species previously was recorded in the Southeast from Georgia, Arkansas, and South Carolina, with a doubtful record for Louisiana (*193*). Collections during and immediately following World War II have added Mississippi (*245, 225*), North Carolina and Tennessee (*228*), Alabama (*230*), and Florida (*53, 66*).

ADULT.—Proboscis dark; palpi very short in both sexes. Occiput with a narrow median stripe of narrow pale scales, and submedian patches of dark broad scales. Mesonotum with fine brown scales except around the prescutellar space, where the scales are pale. Scutellum with the lobes pale-scaled. Lower mesepimeral bristles absent. Wing about 3 to 3.5 mm., the scales dark. Abdomen usually with basal white segmental bands that widen laterally, the bands sometimes incomplete.

LARVA.—Antennal tuft and upper and lower head hairs all multiple. Body glabrous. Lateral abdominal hairs single on segments 3 to 5. Comb of about 15 scales in a partially double row, each tapered to a long point and very finely fringed nearly to tip. Air tube about 4:1, the pecten with one or more of the apical teeth more widely spaced than the others, the ventral hair small, usually with three or four branches, inserted beyond the pecten. Anal segment not completely ringed by plate, the lateral hair very small, double, or triple. Gills nearly twice as long as segments, pointed, one pair slightly longer than the other.

AEDES DORSALIS (Meig.)

There are only two records of occurrence for this species in the Southeast—at Delta, La., (*163*) and at Como, Miss., (*230*). From the latter locality a single female was collected in 1945, and the identification was confirmed by Dr. Alan Stone. It is evidently extremely rare and of no importance in this area. It is widely distributed in the northern and western parts of the United States and Canada, as well as in Asia and Europe. In many places, particularly in the western United States and Canada, it is the dominant species and an important pest of man and animals. It breeds in both brackish and fresh water. Several types of virus of the encephalitides have been isolated from wild-caught *A. dorsalis* in the Western States and Canada.

ADULT.—Proboscis and palpi speckled with white. Occiput with a large median area of pale scales, bordered laterally with dark. Mesonotum with yellowish-white scales laterally and posteriorly, a median dark stripe of variable width extending to about the posterior third. Scutellar lobes pale-scaled. Lower mesepimeral bristles present. Wing about 4 mm., extensively pale-scaled, speckled with dark. Femora, tibiae, and first tarsal segments well speckled with pale scales; segments 1 to 4 of hind tarsi with both basal and apical white rings, segment 5 all white; fore and mid tarsi with similar very narrow rings on first three segments, the last two usually all dark.

Abdominal tergites almost entirely pale-scaled except for quadrate, submedian dark spots on most of the segments.

LARVA.—Antennal hair multiple; upper and lower head hairs single. Body glabrous. Comb scales in a patch, each rounded and fringed apically and laterally, the spinules at apex fairly long, subequal. Air tube about 3:1, tuft beyond pecten; distal teeth of pecten evenly spaced. Anal segment with the plate covering about half the segment, the lateral hair single. Gills very short, less than half as long as segment, bluntly pointed.

AEDES DUPREEI (Coq.)

This rare mosquito has a broad, median mesonotal stripe of silvery-white scales similar to that of *A. atlanticus,* but it is a considerably smaller mosquito and the scales on the occiput differ. It breeds in temporary rain pools but the larvae are seldom collected, owing in part to their habit of hiding in the leaves and trash at the bottom of the pools, where they are able to remain for long periods without coming to the surface. They are easily recognized by their extremely long and sinuous anal gills. The adults are taken in light traps. Apparently nothing is known about their biting habits or host preferences.

With records of occurrence in Tennessee (*230, 290*), this mosquito has been recorded in all of the Southeastern States. Its range extends from Texas, Kansas, and Illinois to New Jersey.

ADULT.—Proboscis and wing unmarked. Occiput with a narrow median line of pale lanceolate scales, bordered by broad pale scales, and with dark scales laterally. Mesonotum with a broad stripe of silvery white scales extending the full length of the scutum, usually somewhat narrower than the dark area on each side. Lower mesepimeral bristles absent. Wing length about 3 mm. Mesonotum of male entirely silvery-scaled or with a very broad median stripe. Tarsi all dark except for pale scaling on the under side of the first hind segment. Abdominal segments unbanded but with lateral basal white spots. Male claspette with a slender stem and filament, the latter slightly longer than the stem and tapered to a sharp point; stem of claspette with a bristle arising from a raised tubercle near base.

The females are very similar to those of *Aedes atlanticus* and *A. tormentor,* but differ in their smaller size and in slightly different scaling of the occiput and first hind tarsus. The males have more extensive pale scaling on the thorax, and the claspette is distinctive.

LARVA.—The larvae are immediately recognized by extremely long, sinuous gills. Antennal and preantennal hairs usually double, sometimes triple; lower head hairs double or triple, the upper single, both simple or sparsely spiculate. Body glabrous. Lateral abdominal hairs single on segments 3 to 5. Comb, a single row of scales, each thorn-shaped and finely fringed laterally. Air tubes about 3.5:1, tuft multiple, inserted beyond the pecten, the latter with evenly spaced teeth. Anal segment completely ringed by the plate, the lateral hair single. Anal gills about as long as entire body, with prominent, dark tracheae.

AEDES FULVUS PALLENS Ross

(Syn., *A. bimaculatus* (Coq.) in part; *A. fulvus* Dyar (not Wied.) in part.)

This is a large, bright yellowish mosquito of striking appearance. The subspecies *pallens* was described in 1943 (*269*) from specimens taken in New Orleans in 1914. It was previously identified in the Southeastern States as *bimaculatus,* but that species was shown to be distinct and to occur only in Texas and Mexico. The type form of *fulvus* is found in the American Tropics and is not known to occur in the United States. Subspecies *pallens* is usually rare, but was encountered by the senior author in con-

siderable numbers on one occasion in 1914 in the vicinity of New Orleans. The larvae were found in temporary pools in dense woods and the adults were fierce biters. Large numbers were reared near Wilson Dam by Belkin (*213*). Thibault found it to be rare in Arkansas but occasionally present about dwellings. With a record of the occurrence of *pallens* in Tennessee (*290*), it is now known to occur in all of the Southeastern States, and has also been recorded from most of the immediately adjoining States, as well as Illinois and Maryland.

ADULT.—Proboscis and palpi yellow-scaled, tipped with dark. Occiput entirely covered with yellowish scales, narrow on the dorsal area, broad and flat laterally. Mesonotum with both the scales and integument a bright yellow, and two prominent, shiny, elongated black spots on the posterior corners. Faint submedian lines along the middle of the scutum. Scutellum with narrow brownish scales. Lower mesepimeral bristles absent. Wing length about 4.5 mm. Costa, subcosta, and vein 1 yellow-scaled from base to tip of the subcostal vein. Femora, tibiae, and first two tarsal segments largely yellow-scaled except for dark rings at tip, the last three tarsal segments all dark or nearly so. Abdomen with prominent basal yellowish bands that widen laterally, segment 7 completely yellow and segment 6 largely so.

LARVA.—Antennal and preantennal hairs multiple; upper head hair single, the lower double or triple. Body glabrous. Lateral abdominal hairs on segments 3 to 5 single. Comb of many scales in a patch, each rounded and fringed with subequal spinules. Air tube about 2:1, the pecten with the last tooth widely separated from the others and attached at about the apical third of tube; tuft large, multiple, inserted before the end of pecten. Anal segment ringed by plate, lateral hair single or double, gills about 1.5 times as long as segment, pointed.

AEDES GROSSBECKI D. and K.

This rare northeastern species has been reported from a few scattered localities in the Southeast. The mesonotum has lateral patches of silvery white scales on the anterior half, somewhat similar in this respect to *A. thibaulti*, but the tarsi have white rings and the wings and legs are speckled. It breeds in woodland pools, and in the North is said to be occasionally fairly numerous and to attack man. In Louisiana, larvae were collected in January and April, and were associated with *Culex restuans, Aedes canadensis*, and *Culiseta inornata* in semipermanent pools. It was thought to have only a single annual generation (*332*).

A. grossbecki was previously listed (*193*) from Mississippi, Louisiana, and Arkansas. There is an additional record from Tennessee (*290*).

ADULT.—Proboscis and palpi sprinkled with white. Occiput with a large median patch of narrow white scales. Mesonotum with a patch of silvery-white scales on each side anteriorly, reduced to narrow lateral stripes posteriorly, somewhat similar to the markings of *A. thibaulti* (fig. 19, *D*). Prescutellar space surrounded by white scaling. Scutellum with narrow white scales on the lobes. Lower mesepimeral bristles usually present but may be absent. Wing length about 4.5 mm., the scales very broad, dark intermixed with white. Femora, tibiae, and first tarsal speckled with white, tarsal segments with basal white rings. Abdomen with broad, basal, segmental, white bands. The broad wing scales and silvery-white markings on the thorax distinguish this species from *A. stimulans*.

LARVA.—Antennal hair multiple; lower head hair usually double, the upper usually triple. Lateral abdominal hairs double on segments 3 to 5. Comb scales in a patch, each rounded, the apical spinule long, the subapical pair about two-thirds as long; the others progressively shorter. Air tube about 3:1, the tuft multiple, attached beyond pecten. Anal segment not ringed by plate, the lateral hair single. Gills pointed, shorter than segment.

AEDES INFIRMATUS D. and K.

Aedes infirmatus is recognized by the large silvery-white patch on the anterior half of the thorax. The tarsi are unbanded. It breeds in temporary woodland or open grassy pools, and at times becomes very abundant and annoying. In common with most of the other woodland species, the females attack readily during the day in or near woods, and at night they may be encountered in the vicinity of dwellings. They may enter houses to bite when excessively numerous. At Yukon, near Jacksonville, Fla., out of a total of nearly 125,000 mosquitoes collected in light traps during the years 1948-1953, about 6,000 were *infirmatus*, with an equal number of *Psorophora confinnis*. These two were the most numerous of the pest mosquitoes taken by Knight (*202*). In a study of a single heavy brood that emerged in April 1953, Knight (*203*) found the adults congregating in numbers about shaded doorways, in shrubbery along buildings, in open garages, and every protected building corner. They seldom entered the buildings but were found in swimming-pool shower rooms. It was of only moderate importance as a biter after dusk. Sparse breeding was reported to occur at that latitude in the winter months.

This species was previously reported from all but two of the Southeastern States (*193*), and recent records for Alabama (*228, 230*), and Tennessee (*290*) complete the list for these States. Of the adjoining States, the species has been reported only from Texas. In Louisiana, the virus of western equine encephalitis was twice recovered from pools of wild-caught *infirmatus*, indicating its potential importance as a vector (*196*).

ADULT.—Proboscis and tarsi unmarked. Occiput with a large median area of pale narrow scales and smaller submedian patches of broad yellowish-white scales. Mesonotum with a wide conspicuous patch of silvery-white scales on anterior half, wider than the dark lateral patches and extending slightly beyond middle of scutum; scales on posterior half dark brown, the prescutellar space bordered with white. Mid lobe of scutellum with a small patch of white scales, the remainder dark. Wing 3.5 to 4 mm. in length, the scales all dark. Abdomen unbanded, but with lateral basal white spots visible from above on some segments. Male claspette with a backward pointing (retrorse) spine about the middle of the filament, but without additional bristles as found in *A. scapularis*.

LARVA.—Antennal and preantennal tufts multiple. Upper and lower head hairs single. Body sparsely pilose. Lateral hairs single on segments 3 to 5. Comb scales in a patch, each thorn-shaped, with the lateral spinules less than half as long as the apical spine. Air tube about 2.5:1, the pecten with evenly spaced teeth extending to about the middle of the tube, the tuft multiple, inserted beyond pecten. Anal segment completely ringed by plate, the lateral hair single or forked. Gills nearly twice as long as the segment, pointed.

AEDES MITCHELLAE (Dyar)

This comparatively rare species resembles *Aedes sollicitans*, with wide rings on the proboscis and tarsi, and a median longitudinal stripe on the abdomen. It lacks the white ring in the middle of the first hind tarsal segment, and the wings are not speckled. It breeds in open, temporary pools, but not, so far as known, in dense woodland. In central Florida, where it frequently was encountered in the piney flatwoods country, its typical breeding places were shallow depressions, sparsely overgrown with tufted

grass and weeds in rough pastureland surrounded by scattered pine woods and palmettos. These flat depressions were often up to an acre or more in size, and the floodings were usually very transient. Breeding was never very heavy. When the depressions were dry, larvae could be obtained from sod samples containing tufts of grass when placed in containers and covered with water. The females were encountered near the breeding places and were rather severe biters. They were reported to become quite annoying in the woods near Gainesville, Fla., (A. J. Rogers, personal communication). The adults have been taken also in light traps. In Mississippi, Michener (*225*) found the larvae in shallow pools in springhead areas, which held water for fairly long periods and usually contained grass or other emergent vegetation. While the species has not been found breeding in salt marshes, it has been taken most frequently in the Coastal Plain. It has also been recorded from several inland States.

This mosquito was previously reported from all seven of the Southeastern coastal States (*193*) and has since been taken in the two inland States of Arkansas (*54*), and Tennessee (*290*). Outside of this territory it has been reported from Texas and New Mexico to Illinois and New York. The virus of eastern equine encephalitis has been recovered from pooled lots of *mitchellae* collected in Georgia (*176*).

ADULT.—Proboscis with a broad white ring. Mesonotum golden in color as in *sollicitans*. Wing about 4 mm. in length, the scales all dark. Fore and mid tarsi with narrow white basal rings on segments 1 to 3, the hind tarsi with wider rings on segments 1 to 4 and segment 5 all white. Dark-scaled areas of femora and tibiae speckled with white. Abdominal tergites with narrow, basal white bands and central pale patches forming an almost continuous longitudinal stripe, as in *sollicitans*.

LARVA.—Lower head hairs single, the upper, usually single but sometimes double. Antennal tuft multiple, the branches spiculate. Body glabrous. Lateral abdominal hairs on segments 3 to 5 single or double. Comb scales in a patch, the single scale thornshaped. Air tube about 3:1, with a multiple ventral tuft beyond the pecten. Anal segment completely ringed by the plate, the gills slightly longer than the segment and somewhat pointed.

AEDES SCAPULARIS (Rondani)

(Syn., *A. euplocamus* Auct., not D. & K.)

This tropical species has a large patch of silvery-white scales on the front half of the thorax and is identical in appearance with *Aedes infirmatus*. Its identification depends on slight differences in the larva and male terminalia. The occurrence of *A. scapularis* in the Southeastern States is based on the collection of three fourth-instar larvae from a rainwater pool on Key Vaca, Monroe Co., Fla., in 1945, originally identified as *A. euplocamus* D. & K. (*232, 252*). It has not been found since and may not be established in that area, but if so, its occurrence would not overlap the present known range of *infirmatus*, as the latter has not been found on the Keys. The species is common in parts of the American Tropics and has also been reported from the lower Rio Grande Valley, Texas. It is susceptible to experimental infection with the virus of yellow fever.

ADULT.—Proboscis dark; occiput with a small median area of narrow pale scales and larger submedian patches of broad, appressed, yellowish-white scales. Anterior patch of silvery-white scales on mesonotum similar to

that of *Aedes infirmatus* but somewhat wider, covering nearly the entire width of the scutum; posterior part of mesonotum including the prescutellar space and lobes of scutellum covered with fine golden-brown scales. Abdominal tergites with more or less distinct median, basal, triangular patches of dingy-white scales, tending to be produced to posterior border on segments 5 to 7; large lateral spots of pure white scales, hardly visible dorsally. In the males of both *scapularis* and *infirmatus*, the claspette has a retrorse, or backward-pointing, spine about the middle of the filament, but in *infirmatus* there are several small bristles in the angle formed by the spine, whereas these are lacking in *scapularis*.

LARVA.—The body of *scapularis* is more densely pilose than that of *infirmatus*, and the comb scales are rounded and fringed with subequal spinules instead of thorn-shaped.

AEDES SOLLICITANS (Wlk.)

(The eastern salt-marsh mosquito)

This common salt-marsh mosquito has wide white rings on the tarsi and proboscis, the thorax is golden-brown, and the abdomen has a median longitudinal white stripe. It occurs in all types of salt marshes along the Atlantic and Gulf Coasts and, except in southern Florida, is usually by far the most important of the salt-marsh species. The larvae are found on the parts of the marsh not reached by daily high tides, usually in potholes or depressions of various sizes, but often over extensive areas of nearly level marsh. The eggs are laid on almost any moist place in such marshes and also in low grassy lands immediately adjacent. Hatching occurs when the land is covered with rainfall or with monthly or seasonal high tides (spring tides), and enormous numbers may be produced in a single brood. The kinds of vegetation growing on the marshlands vary a good deal with the elevation, some being more tolerant of frequent floodings than others. With a little experience, one can often determine whether a particular place is a potential breeding ground by the kind of vegetation present. The eggs can withstand long periods of drying, and the percentage of hatching with each flooding is variable.

The females are fierce biters and strong fliers. They commonly migrate in large swarms many miles from the coast, distances of 40 or 50 miles being not unusual, although the great majority probably stop much closer. In Florida, specimens sometimes are taken in the interior of the peninsula when broods have emerged on the coast. The flight of migratory swarms begins just before dark, and the numbers that may be encountered at this time are almost unbelievable. The adults settle in the grass and shrubbery during the day and are extremely annoying, often unbearably so, to persons and domestic animals, attacking even in full sunlight. In the southern half of Florida the species may be found throughout the winter, usually in small numbers, and more prevalent during the cooler months than in the summer. The relative numbers there seem to vary considerably from year to year. The distribution of the two species in Florida, and relative abundance in a few other localities, is discussed in the notes on *taeniorhynchus*.

The virus of western and eastern equine encephalitis has been transmitted experimentally with this species by several workers. Its vector potential was rated as "excellent" for the eastern type and "good" for the western type by Chamberlain *et al.* (*72*).

A. sollicitans has been reported from all the Southeastern States except Tennessee (*193*). It occurs in all the Atlantic and Gulf Coast States from New Brunswick to Texas, and has been reported from a number of inland States, particularly the Midwest, where it is associated with salt water from oil or artesian wells. In Illinois and Indiana it bred abundantly in areas intermittently flooded with salt water from swimming pools or oil wells, and in one pond flooded with acid waste from the shaft of a coal mine (*108*). In one of the localities in Illinois (Dupo) the salinity of the water in which breeding occurred was three times that of average sea water (*270*). It has been reported as well from Kansas, Nebraska, Missouri, North Dakota (*311*), and other States. In Oklahoma the larvae were found in salt-water pools which form at the edges of the Great Salt Plain near Cherokee (*275*). The species occurs also in the West Indies.

ADULT.—Proboscis with a wide central white ring. Palpi white-tipped. Occiput with a large patch of pale lanceolate scales bordered laterally with a narrow line of dark scales. Mesonotum and scutellum with golden lanceolate scales. Lower mesepimeron either bare or with a single bristle. Wing about 4 mm., with white scales mixed with the brown, the lateral or plume scales narrow. Femora and tibiae speckled with white, the tarsal segments with broad basal white rings, segment 1 with an additional broad ring in the middle and segment 5 all white on all tarsi. Abdomen with basal segmental white or yellowish bands and a median white stripe extending the full length. *A. mitchellae* is the only other species in our area with a longitudinal stripe on the abdomen, but it differs in having the wing scales entirely dark, and the first tarsal segments are without a central white ring.

LARVA.—Upper and lower head hairs single, the antennal tuft multiple. Body glabrous. Comb scales in a patch, the scales thornlike, fringed on each side toward base. Air tube short, about 2:1, the ventral tufts multiple and inserted beyond the pecten. Dorsal preapical spines about as long as the apical pecten teeth. Anal segment ringed by the plate; the gills very short, budlike, but may be somewhat longer in specimens that develop in fresh water. The larvae, although very similar to those of *A. mitchellae* and *A. infirmatus*, can usually be distinguished readily by the much shorter gills and a somewhat shorter air tube. *Infirmatus* also differs in being sparsely pilose, at least on the thorax, and having the dorsal preapical spines of the air tube much shorter than the apical pecten tooth.

AEDES STICTICUS (Meig.)

(Syn., *A. hirsuteron* (Theob.))

This species is distinguished by having the sides of the mesonotum pale-scaled and with a broad central stripe of brown scales, usually divided by a fine median line of yellowish scales; the tarsi unbanded. It is typically a floodwater mosquito, and occurs chiefly in the spring. There is one generation a year (*213*). The females may migrate several miles and are fierce biters. Very large broods appear at times in some of the northern and western States and Canada under flood conditions, and become a serious menace to man and animals. In the South the species is widely distributed but seldom abundant. Thibault (*303*) found the larvae in Arkansas in temporary grassy pools in fields and thickets from March to May, and in rain pools during the summer. The females attacked in the woodlands but did not enter buildings. In Tennessee it was reported to be relatively abundant. The larvae occurred in floodwaters and were taken associated with six other species, chiefly *A. vexans* (*290*). In southern Mississippi it was very troublesome in the spring and was a serious pest within a radius of about 2½

miles from the breeding place. The larvae occurred in shaded pools left by high river water (*225*).

The species is widely distributed from coast to coast in the United States and Canada, as well as in Europe and Northern Asia. It was listed from all the Southeastern States (*193*), and a number of records within these States have been added, following more recent collections.

ADULT.—Proboscis dark. Occiput largely silvery-scaled, the scales narrow on the dorsal area. Mesonotum with a broad central stripe of brownish or golden scales, usually divided by a fine median line of yellowish scales. Sides of scutum and antescutellar space with silvery-white scales. Lobes of scutellum with narrow yellowish scales. Lower mesepimeral bristles absent. Wing length about 4 mm., the scales dark. Dark portions of femora and tibiae heavily speckled with white, the tibiae and first tarsals pale on one side for nearly their entire length; tarsi not ringed. Abdomen with white, basal segmental bands, widening laterally.

LARVA.—Antennal and preantennal tufts of larva multiple. Lower head hair usually double, the upper with two to four branches. Body glabrous. Lateral abdominal hairs double on segments 3 to 5. Comb scales in a small patch, each thorn-shaped with fine lateral spinules. Air tube about 3:1, tuft multiple, inserted beyond pecten. Anal segment not completely ringed by plate, lateral hair single, gills about twice the length of segment.

AEDES STIMULANS (Wlk.)

(*Syn., A. stimulans mississippii* Dyar, etc.)

Aedes stimulans is a speckled mosquito with broad white rings on the tarsi and broad basal abdominal bands. The proboscis is not ringed and the thorax is not definitely ornamented. It is a northern forest and floodwater mosquito that has been recorded once from Mississippi (Electric Mills). These specimens were named *A. stimulans mississippii* by Dyar in 1920, but the subspecies was later dropped as a synonym and the species has not again been reported from the South. It is widely distributed in the northern States and Canada, and is an important woodland pest in some places.

ADULT.—Proboscis and palpi dark, sprinkled with white. Occiput largely pale-scaled. Mesonotum with light brownish scales often somewhat darker in the median area except around prescutellar space. Lower mesepimeral bristles present. Wing about 4.5 mm., well sprinkled with white; lateral wing scales narrow. Hind tarsi with broad basal white ring on all segments, front and mid tarsi with narrower rings on segments 1 to 4, segment 5 all dark. Abdominal segments with broad basal white bands.

LARVA.—Antennal and preantennal hairs of larva multiple. Upper head hair usually double, the lower single. Body glabrous. Lateral hairs usually double on abdominal segments 3 to 5. Comb scales in a patch, each rounded and fringed, the apical spine long and stout, the preapical pair slightly over half as long, and the others progressively shorter. Air tube about 3:1, ventral tuft multiple, inserted beyond pecten. Anal segment not completely ringed by plate, the lateral hair single. Gills pointed, about as long as segment.

AEDES TAENIORHYNCHUS (Wied.)

(Syn., *Taeniorhynchus niger* of Giles (not Theob.); *Culex portoricensis* (Ludl.); the black salt-marsh mosquito.)

This small black and white mosquito has sharp, contrasting white rings on the proboscis and tarsi (fig. 22), somewhat narrower than in *Aedes sollicitans*. It lacks the longitudinal stripe on the abdomen and the central ring on the first tarsal segment.

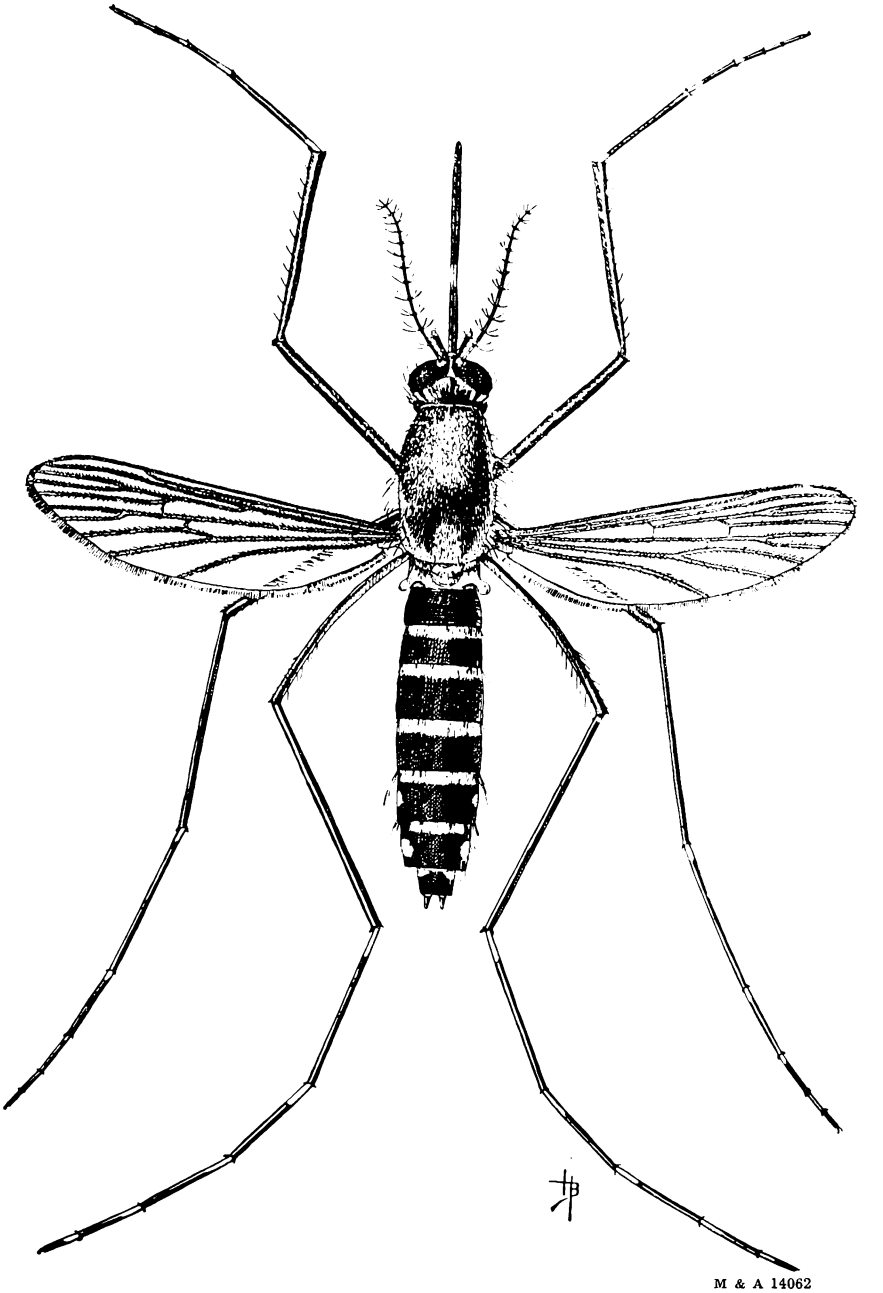


FIGURE 22.—*Aedes taeniorhynchus*, one of the salt-marsh mosquitoes.

It is the most abundant and troublesome species along at least the southern two-thirds of the Florida coasts, which is also approximately the area where mangrove and pickleweed (saltwort) form the predominant marsh vegetation (pl. 6). Farther north and west it is usually outnumbered by *A. sollicitans*. From extensive light-trap collection records obtained by the Florida State Board of

Health, Provost (*254*) states that the points at which the two species occur in about equal numbers are the mouth of the St. Johns River on the Atlantic Coast and the mouth of the Suwannee River on the Gulf Coast. North of this 50-50 line the salt marshes are of the grassy-sod type (*Spartina, Distichlis, Sporobolis*) while south of this line they are of non-sod type (*Batis, Salicornia, Sesuvium,* mangrove). At the Alabama-west Florida line, *sollicitans* predominated up to 50:1, whereas *taeniorhynchus* reached a ratio of 1000:1 on the Keys. While *taeniorhynchus* usually is not the predominant species north of Florida, there are a few records of collections in which they outnumbered *sollicitans*. At Charleston, S. C., collections in four light traps, operated nightly over a period of about 100 days in 1939, gave a total of nearly 10,000 *taeniorhynchus* compared with about 200 *sollicitans* (*111*). On Parris Island, S. C., *taeniorhynchus* was the most abundant species in all types of collections from June to September 1945 (*26*). In light-trap collections at Fenwick Island lighthouse in southern Delaware in 1940, the total counts over a 60-day period, excluding the collections for one night, showed nearly equal numbers of the species (totals of about 6,500 of each from two traps) (*208*). On the one night, September 10, the enormous total of 271,772 mosquitoes was taken in a single trap, of which about 192,000 were *taeniorhynchus* and 70,000 *sollicitans*. On the other hand, light-trap collections in 50 localities in New Jersey during the 10-year period from 1932 -1941 gave a *sollicitans-taeniorhynchus* ratio of about 45:1 (*145*).

The breeding habits of *taeniorhynchus* are similar to those of *sollicitans*. Eggs are laid in similar locations and the larvae are found in parts of the marsh above the level of the daily high tides. The most prolific breeding occurs in potholes and temporary ponds in *Batis* and *Distichlis*, but often over extensive areas of *Batis* and mangrove, or in land-locked coastal swales. Larvae are frequently found in fresh-water pools on vacant lots, golf courses, and pastures near the coast. Many larvae were found once by the writers in fresh water standing on a vacant lot within the city limits of Orlando in the interior of Florida—the only record of the species among many larvae collections in the same locality.

The females are persistent, hard biters, and appear at times in unbearable numbers. They seem much less inclined than *sollicitans* to attack in bright sunlight, but are commonly very annoying in the shade in the mangrove or other forests, or in shrubbery about dwellings. They are migratory and disperse many miles from their breeding places. The females were troublesome at times in the vicinity of Orlando, Fla., which is about 30 miles from the nearest salt water. Provost (*255*) has given other records on the occurrence of salt-marsh mosquitoes in the interior of the State. The same author (*256*) reported preliminary studies of the dispersal of *taeniorhynchus* from Sanibel Island, off the Florida west coast, in which mosquitoes were marked by means of radiophosphorus (P^{32}). He reported that a non-purposive flight occurred from one to four days after emergence and carried the females to the limits of the collecting area, 20 miles, and probably beyond. The light-trap collection showed a five-day cycle of numbers, and the last radioactive specimen was caught on the

19th day. Dispersion appeared to be at random in all directions, periodically repeated from foci established by previous migration.

From studies near Fort Pierce, Fla., Nielsen and Nielsen (*239*) reported that biting showed a 5-day cycle, being most intensive when the females were about 4, 9, and 14 days old. Females ready to lay eggs performed a special flight, which occurred when they were about 7, 12, and 17 days old. Most of them lived three or four weeks and some of them much longer. Nielsen and Haeger (*237*, *238*) reported that emergence of a brood was spread out over two or three days, with a 3-hour outburst (when most of the emergence took place) at some time during the 24-hour period. The outburst occurred at the same time each day for one brood, but the time varied with different broods. Newly emerged mosquitoes remained around the breeding place for 4 to 6 hours and were then ready for the exodus, which took place only at night. If emergence occurred between midnight and early afternoon, the exodus took place the last half of twilight. Otherwise, the exodus took place later in the night. So far as known, mating usually occurred within the first 24 hours of female life. Swarming of males usually did not begin until three or four days after emergence and, in the opinion of the authors, had no purpose of releasing any other reflex mechanism; i. e., it was not for mating purposes, as commonly supposed.

Experimental transmission of several strains of encephalitis virus by *A. taeniorhynchus* has been reported by several workers, and Pistey (*248*) found it to be a suitable host of *Dirofilaria tenuis* of raccoons.

A. taeniorhynchus has been listed from all the Southeastern States except Tennessee (*193*), and these records include inland locations in Arkansas and northwestern Louisiana. There are, however, no records of its occurrence in the Midwestern States, where *A. sollicitans* has been found. It ranges along the Atlantic and Gulf Coasts from Maine to Mexico, the Caribbean region to northern South America, and on the Pacific Coast from Southern California to Peru.

ADULT.—Occiput with a large median patch of pale lanceolate scales. Mesonotum dark-scaled, sprinkled with white. Wing about 3.5 mm. in length, entirely dark-scaled. Abdomen with basal white segmental bands but lacking the longitudinal stripe of *sollicitans* and *mitchellae*. Front and mid tarsi with narrow basal white rings on segments 1 to 3, sometimes on 4 and 5 also, the rings on the hind tarsi wider but segment 1 lacks the median ring of *sollicitans*. In specimens from the North and Central Atlantic States, the fifth segment of the hind tarsi usually is entirely white. Southern and tropical specimens having the tip dark are sometimes classified as a variety —*niger* or *portoricensis*.

LARVA.—Upper and lower head hairs each single, antennal tuft small, double or triple, simple. Body pilose. Lateral hairs of segments 3 to 5 branched three or more times. Comb scales in a patch, each rounded and fringed with subequal spinules. Air tube short, 2:1 or less, with a multiple tuft beyond the pecten, the dorsal preapical spine about equal in length to the apical pecten tooth. Gills usually very short, budlike, but may be longer when the larvae develop in fresh water.

AEDES THELCTER Dyar

(Syn., *A. keyensis* Buren)

This species is known in the Southeastern States only from the Florida Keys. The thorax is largely pale-scaled, with an indistinct

median stripe of darker scales. The abdominal segments have large median basal, triangular white patches, and the proboscis and tarsi are unbanded. It was first reported on the Keys from the collection of five females taken in light traps at Key West and Marathon in October and November 1946 and named as a new species—*Aedes keyensis*, by Buren (*62*). This name was subsequently synonymized with *A. thelcter* by Thurman *et al.* (*305*), who obtained numerous larvae of the species on Long Key and at Rock Harbor on Key Largo in 1947. One female each was taken subsequently on Big Coppitt Key, Crawl Key No. 1, and Vaca Key (*53*). The breeding places were temporary rain pools in depressions in the limestone strata. The pool on Long Key was at the edge of a buttonwood transition zone between hardwood forest and a mangrove swamp. It was densely shaded by the surrounding tree growth and was filled with a thick mat of purslane (*Sesuvium*), but free of permanent aquatic vegetation. Holes of the land crab were present in the depression. Nine species of associated mosquitoes were listed, including *Deinocerites cancer, Aedes tortilis, A. taeniorhynchus* and *sollicitans, Psorophora johnstonii,* and several other species of *Psorophora.* Two females were taken in biting collections.

In addition to the collection referred to above, Thurman *et al.* (*305*) reported 12 light-trap records from Marathon and Key West and 2 from Vaca Key. The species previously has been known only from a few localities in Texas, Oklahoma, and Mexico.

ADULT.—Proboscis dark. Occiput with a median area of pale lanceolate scales, broad ones laterally. Mesonotum clothed with narrow, curved, yellowish scales, usually with a more or less distinct median stripe of pale brown scales. Lower mesepimeral bristles usually absent. Wing about 3 to 3.5 mm., the scales all dark. Tibiae and first tarsals pale-scaled on one side, the other tarsal segments entirely dark. The abdomen has unusual markings consisting of large triangular spots of white scales at the base of the segments, sometimes prolonged and widened apically on the posterior segments; segment 7 largely pale-scaled.

LARVA.—Antennal and preantennal tufts multiple. Upper and lower head hairs single. Body glabrous. Lateral abdominal hairs single on segments 3 to 5. Comb of about 20 scales in an irregular row, each with a long apical spine and much shorter side spinules, the preapical pair not more than half as long. Air tube about 2:1, the pecten with one or two apical teeth more widely spaced than the others, the ventral tuft multiple, inserted well before end of pecten. Anal segment ringed by plate, the lateral hair usually double. Gills about as long as the segment.

AEDES THIBAULTI D. and K.

This comparatively rare mosquito is recognized by the lateral patches of yellowish-white scales on the anterior half of the scutum, separated by a broad stripe of dark scales. The proboscis, tarsi, and abdomen are unbanded. It breeds exclusively in the stump holes and basal cavities of several species of gum trees, and occasionally in the basal cavities of cypress. It has not been found in ordinary tree holes above the flood level of the swamps. Information on its habits has been published in a number of articles (*42, 157, 288*) which were summarized by Jenkins and Carpenter (*174*). The eggs are probably laid on the inner walls of the stump or tree cavities and the winter is passed in this stage. The eggs hatch in the spring when flooding occurs, and larvae have been taken from March to May. The eggs may remain

viable for more than a year if flooding does not occur (*158*). There is only one generation a year but there may be a succession of broods when irregular hatching occurs. Larvae of *Aedes triseriatus, Culex apicalis* (= *C. territans*), *C. restuans,* and *Culiseta melanura* have occasionally been taken in association with *thibaulti.* The adults remain close to the breeding places but bite readily and become annoying in the daytime in these locations. They are found resting in hollow trees and stumps, and occasionally about dwellings (*303*). They are not considered to be of any practical importance.

Since the previous publication (*193*), State records have been added from Florida (*228, 53*) and Tennessee (*66*), which completes the list of the Southeastern States. Outside this area are scattered records only from Kentucky, southern Illinois, and eastern Texas.

ADULT.—The proboscis and tarsi of this species are unmarked. Occiput with yellowish-white scales on the median area, a small submedian patch of broad dark scales on each side. Mesonotum with broad lateral patches of yellowish-white on the anterior half, reduced to narrow lateral stripes on the posterior half by an abrupt widening of the median dark-scaled area (fig. 19, *D*). Prescutellar space surrounded by pale scales. Lobes of scutellum pale-scaled. Posterior pronotum with narrow, curved, pale scales. Lower mesepimeral bristles usually absent. Wing length about 4 mm., the scales all dark. Dark portions of femora not speckled with white. Abdominal segments with large lateral, basal, white spots visible from above

LARVA.—Antenna nearly as long as head. Antennal, preantennal, and both the upper and lower head hairs large and multiple. Body glabrous. Upper lateral hair, or both pairs, on abdominal segments 1 and 2 multiple, lateral hairs double on segments 3 to 5. Comb scales in a patch, each rounded and fringed, the apical spine long and strong, the preapical pair nearly as long and the others progressively smaller. Air tube about 4:1, the ventral tuft multiple, inserted beyond the pecten. Anal segment not completely ringed by plate, the lateral hair single. Gills pointed, about as long as segment.

AEDES TORMENTOR D. and K.

The females of *Aedes tormentor* are indistinguishable from those of *A. atlanticus,* both having a broad median stripe of silvery-white scales on the thorax and unbanded tarsi. Identification depends on the larvae or male terminalia. It breeds in temporary rain pools in woodlands, and the larvae usually have been found associated with *A. atlanticus,* but in much smaller numbers. At New Orleans, La., however, they were taken more often than *atlanticus* in the Metarie woods. The species has been recorded from all the Southeastern States except Tennessee (*193*).

ADULT.—The proboscis and tarsi are unmarked. Occiput with a large median area of white narrow scales, bordered by broad, appressed, mostly dark scales. Median thoracic stripe extends the entire length of scutum and is somewhat narrower than the dark area on each side. Lower mesepimeral bristles absent. Wing about 3.5 to 4 mm., the scales dark. Abdomen unbanded, with basal, lateral, white segmental spots. Stem of male claspette long and slender, slightly pilose basally but without a bristle near middle; filament much shorter than stem, pointed, and slightly hooked at tip.

LARVA.—Antennal and preantennal hairs multiple. Upper and lower head hairs single, sparsely spiculate. Body glabrous. Lateral abdominal hairs usually single on segments 3 to 5. Comb with 9 to 12 scales in a single row, each thorn-shaped and finely fringed laterally. Air tube about 2:1, the pecten extending to the apical third of tube, with evenly spaced teeth, the ventral tuft inserted before end of pecten. Anal segment ringed by plate, the lateral hair single or double. Gills pointed, somewhat longer than segment. Specimens taken in Florida sometimes have the thorax and eighth abdominal segment

white in striking contrast to the rest of the body. A specimen collected at Parris Island, S. C., was similarly marked.

AEDES TORTILIS (Theob.)

This small species is known in the United States only in southern Florida. The thorax is largely pale-scaled with a pair of submedian dark stripes and a narrow border of dark scales laterally. The proboscis and tarsi are unbanded. The first specimen to be recorded in Florida was a female caught in a light trap at Key West in August 1945. A dead female was found about the same time on a plane arriving in Miami from the Tropics (*295*). Additional collections have been reported from Vaca Key, Cudjoe Key, and Stock Island in Monroe County, and from Dade, Hendry, and Palm Beach Counties on the mainland (*232, 252, 53*). Except for the biting records, there is no information as to habits. One of the authors (*232*) mentions the collection of several larvae but the breeding places are not given. This mosquito is known from the Greater Antilles and the Bahamas, and is said to breed in ground pools. In Jamaica, larvae were collected in July 1957 in honeycomb rock holes on the hillsides above Montego Bay by E. J. Beidler and W. V. King. These larvae were identified by Alan Stone.

ADULT.—Proboscis dark. Occiput with a median patch of narrow silvery-white scales, broad ones laterally. Mesonotum with fine golden-brown scales, divided by a pair of submedian longitudinal stripes of fine black scales; mixed black and golden scales on prescutellar space. Lower mesepimeral bristles absent. Wing about 3 mm., the scales dark. Tibiae and first tarsals with pale stripes on one side, other tarsal segments all dark. Abdominal segments with fairly broad basal white bands on segments 2 to 4, narrow on 5, and usually lacking on 6 and 7. The mesonotal vestiture of the male from Clewiston, Fla., was observed to be entirely white and this sexual difference was noted in reared males from Puerto Rico (*252*).

LARVA.—Antennal tuft multiple. Upper and lower head hairs single. Thorax sparsely pilose. Comb scales in a small patch, each rounded and fringed, the apical spine slender, slightly longer than the subapical. Air tube 2.5-3:1, the tuft multiple, inserted beyond the pecten. Anal segment ringed by plate, lateral hair single. Gills less than twice as long as segment, shorter than the longest hairs in ventral brush.

AEDES TRISERIATUS (Say)

(The tree-hole *Aedes*)

Aedes triseriatus has the sides of the mesonotum covered with silvery-white scales separated by a broad central area of brown scales (fig. 19, *F*). The proboscis and tarsi are unbanded. It is a common woodland species, which breeds principally in tree holes but to some extent also in water barrels and other artificial water containers, and has been reported from pitcher plants (*213*). Larvae have been found in tree holes in gumbo limbo (*Bursera simarubra* Sarg.) on the Florida Keys (*252*). The eggs are laid at or just above the water line. In the North the winter is passed in the egg stage, but farther south larvae may be found throughout the winter. A minimum incubation period of 4 to 6 days at a temperature of about 80° has been reported (*141*). Larval development is quite rapid in comparison with that of other tree-hole breeders. The adults are fierce daytime biters in or near infested woods, and also are annoying about dwellings, where breeding

occurs in domestic water containers or in shade trees on the premises. In Arkansas they were reported to be abundant about homes near woods (*303*). They are readily collected in light traps at night.

A. triseriatus is of potential importance as a disease vector since it is capable of transmitting the viruses of yellow fever (*24*) and equine encephalitis (*84*). Its vector potentials with both the western and eastern viruses were rated "excellent" (*72*). Also it has been found to be a suitable host of dog heartworm *Dirofilaria immitis* (*247*).

ADULT.—Proboscis and tarsi unmarked. Occiput with a large median patch of narrow-curved, white scales. Mesonotum conspicuously marked with stripes of silvery-white scales laterally, becoming narrower posteriorly, the median area broadly dark-scaled (fig. 19, *F.*). Prescutellar space bordered by white scales. Scutellum with a patch of white scales on the mid lobe, dark ones on the side lobes. Posterior pronotum densely covered with broad, appressed white scales. Lower mesepimeral bristles absent. Wing about 4 mm., the scales dark. Abdominal segments unbanded dorsally, with lateral basal white spots, some visible from above.

LARVA.—Antennal hair single, preantennal hair double, lower head hair with 2 to 4 branches, the upper single. Body glabrous. Lateral abdominal hairs double on segments 3 to 6. Comb of 8 to 15 scales in a single irregular row, each elongated, tapered to a rounded point, and evenly fringed with small spinules (fig. 21, *D*). Air tube about 3:1, the tuft usually single or double, inserted beyond the pecten. Anal segment not completely ringed by plate; the tuft multiple. Gills stout, rounded at tip, the dorsal pair about as long as anal segment, the ventral pair shorter.

AEDES TRIVITTATUS (Coq.)

The thorax of this species has a pair of broad submedian stripes of yellowish-white scales separated by a broad stripe of brown scales. The proboscis and tarsi are unbanded. It occurs in most of the Southern States but is rare and considered of no economic importance. No observations on its occurrence in this area have been published other than brief records of its collection. Farther north it is associated with floodwater areas. The females are said to be fierce biters and become rather severe pests in some areas. In Illinois it is one of the extremely annoying species (*270*). In a study of *trivittatus* near Columbus, Ohio (*1*), it was found to breed in temporary pools in open sites and in shallow ditches covered with vegetation. The adults appeared the first week in June associated with *Aedes vexans* and *Psorophora ferox,* and were found up to the first week in September. They were seldom caught in a residential area just beyond the breeding places. *A. trivittatus* has been recorded in all the Southeastern States except Florida, Alabama, and Mississippi (*193*). Its range extends through all the Northern States and southern Canada to the Rocky Mountains.

ADULT.—Proboscis dark. Occiput with narrow, curved, pale scales on the median area, broad white scales laterally enclosing a small patch of dark ones. Mesonotum with a pair of broad submedian stripes of yellowish-white scales, separated by a broad central stripe of dark scales, narrow stripes of dark scales laterally; prescutellar space bordered with pale scales. Lobes of scutellum pale-scaled. Lower mesepimeral bristles absent. Wing length about 3.5 to 4 mm., the scales dark. Dark portion of femora and tibiae not speckled; tibiae and first tarsals slightly pale on one side, tarsal segments not ringed.

LARVA.—Antennal and preantennal hairs multiple. Upper and lower head hairs single. Body sparsely spiculate. Comb scales in a patch, each rounded, with a long, stout apical spine, the two preapical spines about two-thirds as

long and the other spinules progressively shorter. Air tube about 2:1, the tuft multiple, inserted beyond pecten; dorsal preapical spine shorter than apical pecten tooth. Anal segment ringed by plate, lateral hair single. Anal gills about three times length of segment and longer than hairs in the ventral brush.

AEDES VEXANS (Meig.)

Aedes vexans has narrow basal white rings on the tarsal segments and rather broad white bands on the abdomen, notched on the posterior border. The proboscis and thorax are unmarked. The species is widespread in North America and on other continents, and is of great economic importance in many parts of its range. In some areas of the Northern States it is the principal pest mosquito. In New Jersey it was the third most abundant species taken in light traps during the 10-year period from 1932 to 1941, following *Aedes sollicitans* and *Culex p. pipiens* in total numbers. It occurs in all the Southeastern States but is seldom abundant there. The writers have taken occasional specimens in Florida, and it has been collected in light traps by State Board of Health workers in most of the Florida counties (*53*). It was reported to be the most abundant species in Tennessee and an important pest in some localities (*290*). In Mississippi it was reported to be one of the commonest and most troublesome mosquitoes at Camp Shelby (*225*).

The species is primarily a floodwater breeder, and enormous broods are produced when flood plains of rivers and streams are inundated during spring overflows. It breeds also in flooded meadows and in a great variety of temporary pools, usually in open grassy sites or open woodlands, often associated with *Psorophora confinnis* and other temporary-pool breeders. Larval development is variable, depending on temperature, but is very rapid during warm weather. The females are migratory. In Oregon they were found commonly 15 miles from any breeding source, and in lesser abundance as far as 30 miles away (*296*). In Illinois, flight of stained specimens up to 14 miles was recorded (*77*). Both males and females were collected in light traps in Delaware Bay about 8 miles from the nearest shore (*209*).

The eggs are laid in moist depressions, especially those containing decaying organic debris. They may hatch during the same season in which they are deposited, after the usual sequence of incubation, drying, and flooding, so that several generations may occur during the summer under favorable conditions. Experiments in Oregon showed little mortality of dormant eggs over a period of two years, but thereafter they lost viability rapidly (*127*). Very few of the eggs would hatch when flooded with tap water, but a large proportion did so when the oxygen content of the water was reduced by bacterial growth or other means (*125*). Infusions of amino acids and various other substances also acted as hatching stimuli.

This species is capable of experimental transmission of eastern and St. Louis equine encephalitis (*84, 135*), and the virus of the western type has been recovered from it in nature (*63*). Its vector potential was rated "fair" with both the eastern and western viruses (*72*). Laboratory transmission of fowl pox by *vexans* has

been reported (*216*), and it was shown to be a moderately efficient host of *Dirofilaria immitis* (*336*).

ADULT.—The proboscis and thorax of the adult are unmarked. Occiput bears numerous pale scales in the median area. Wing length about 4 mm., the scales dark. Lower mesepimeral bristles absent. Hind tarsi with narrow basal white rings on all segments, front and mid tarsi with very narrow rings usually visible on segments 1 to 3. Abdominal segments with basal white bands which usually show a distinct, inverted, V-shaped notch on the posterior borders, especially on segments 5 and 6.

LARVA.—Antennal and preantennal tuft multiple. Lower head hairs usually with 2 or 3 branches, the upper with 3 to 5. Body glabrous. Lateral abdominal hairs double or triple on segments 3 to 5. Comb with about 10 scales in an irregular row, each thorn-shaped with fine lateral spinules. Air tube about 3:1, the pecten with one or two of the apical teeth more widely spaced than the others, the tuft multiple, inserted beyond the pecten. Anal segment not completely ringed by the plate, the lateral hair single or double. Gills about twice as long as the segment, bluntly pointed.

Genus ANOPHELES Meigen

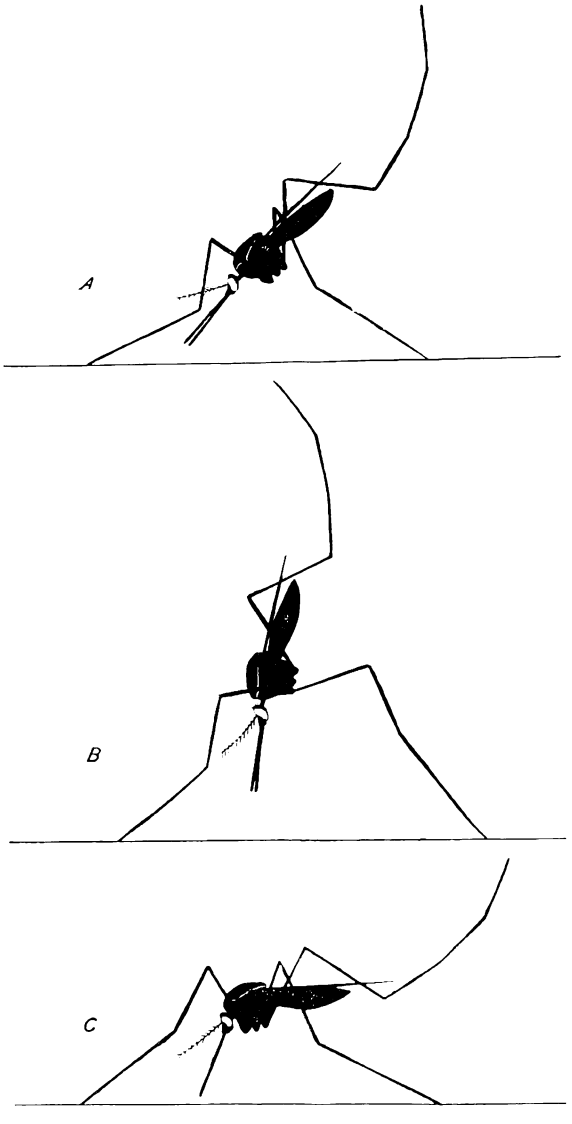
(Syn., *Nyssorhynchus* Blanch.)

The mosquitoes of this genus breed in a wide variety of aquatic environments, although their production on a large scale is chiefly in permanent bodies of water containing vegetation or surface debris. Descriptions of anopheline breeding places of various types, while not specifically referred to herein, are numerous in the literature cited. Some of the references deal with the classification and types of breeding places in given localities, such as, Bradley (*41*) for northeastern Louisiana; Barber and Komp (*13*) and Perez (*244*) for Mississippi; Boyd (*32, 33*) for northeastern North Carolina; Watson and Spain (*319*) for northern Alabama; Meleney *et al.* (*222*) for western Tennessee; and Darling (*83*) for Georgia (Lee County). The bionomics and ecology of the Nearctic species have been reviewed by Bradley and King (*49*), Freeborn (*115*), and others. The works of Boyd (*34, 36*) contain comprehensive reviews of the literature on the natural history of anophelines as well as on the relation of the various species to the epidemiology of malaria.

All our native anophelines are fresh-water breeders, with the exception of *Anopheles atropos* and *A. bradleyi,* which breed in salt or brackish water, and *A. albimanus* which occurs in either brackish or fresh water. The number of generations per year varies greatly; *A. quadrimaculatus* may have from 8 to 10 generations annually in the latitude of southwestern Georgia (*32*). In the fall, inseminated females enter caves and cellars to hibernate. In the warmer sections of the Gulf States breeding also is more or less continuous through the winter (*14, 131*), although much reduced in volume, and the rate of development is slower. The larvae of some species are able to withstand freezing temperatures (*6*). The adults are active chiefly after dusk and spend the daytime resting in dark, humid situations. *Anopheles* are considered to be relatively weak fliers, although migrations of several miles have been recorded. A review of the literature relating to anopheline flight and dispersion has been published by Eyles (*105*).

The eggs of anophelines (fig. 3, *C*) are boat-shaped, pointed on either end, and are laid singly—that is, not stuck together in

rafts—on the surface of the water in permanent pools and ponds where there is emergent or floating vegetation and debris of various kinds. They are provided with floats to keep them at the surface of the water. The meniscuses of individual eggs cause them to be attracted to one another and to form various geometrical patterns on the water surface. Hatching usually occurs in 2 or 3 days, and breeding is continuous during the summer months.



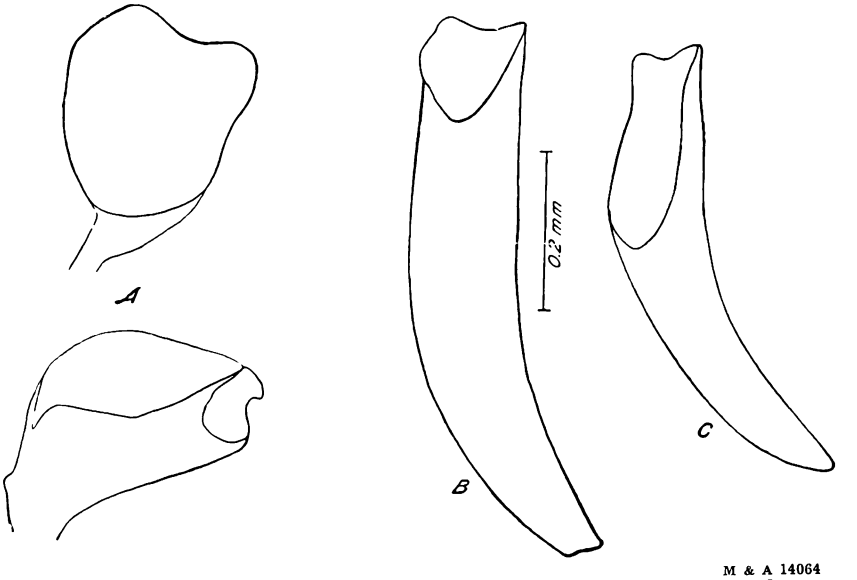
M & A 14063

FIGURE 23.—Resting positions of mosquitoes: *A* and *B*, *Anopheles*; *C*, *Culex*.

Living adults of most species of anophelines can be recognized by their typical resting position (fig. 23, *A*, *B*), the abdomen and proboscis being held in nearly a straight line and pointed at an

angle toward the resting surface. Other kinds of mosquitoes hold the body more or less parallel to the resting surface (fig. 23, *C*), while the head and proboscis are bent downward at an angle to the body. The palpi of anophelines (except in the Australasian genus *Bironella*) are as long as the proboscis in both sexes (fig. 1, *A*, *D*) and are enlarged or somewhat club-shaped in the males. The wings usually have spots of dark or white scales (pl. 8). The posterior border of the scutellum is evenly rounded and fringed with hairs. In all our species except *A. albimanus* the abdomen has a vestiture of fine hairs rather than the flat scales found on most other mosquitoes. *Albimanus* has some flat scales.

The larvae of *Anopheles* are easily recognized by the absence of a breathing tube and by their usual feeding position (fig. 20, *A*) parallel to the water surface. Other mosquito larvae have an elongated breathing tube and while at the surface hang downward with only the tip of the tube penetrating the surface film (fig. 20, *B*). Anopheline larvae have paired, fan-shaped tufts of modified hairs, called palmate hairs, on the upper side of the abdominal segments, and a pair of transparent, notched organs on the front border of the thorax that allows the larvae to suspend themselves just below and parallel to the surface. While in this position the head is rotated for feeding until the mouth parts are uppermost, and the food is taken from or near the surface film. The clypeal hairs, sutural hairs, palmate and antepalmate hairs, and the lateral hairs on abdominal segments 4 and 5 are the characters most frequently used in the identification of anopheline larvae (fig. 13). In the descriptions of these characters the usual range observed in the number of branches or the form of branching is given, although additional variation may occur in a small percentage of specimens.



M & A 14064

FIGURE 24.—Pupal breathing tubes: *A*, *Anopheles crucians*, from above and side; *B*, *Culex salinarius*; *C*, *Culex p. quinquefasciatus*.

Miles (*229*) has reported a study of the variations in the chaetotaxy of series of larvae of *A. bradleyi, georgianus,* and *punctipennis.* Roth (*272*) has recorded the aberrations and variations encountered in a study of large numbers of larvae of the commoner species. He shows that in species in which the inner clypeal hairs are normally simple a considerable number may show some branching. Usually only one hair was found to be forked toward the tip, but in a few specimens there were several branches on one or even both sides. It should be remembered, therefore, that quite atypical individuals may be encountered.

In the pupal stage the breathing tubes are short and widely flared as compared with those of other mosquitoes (fig. 24) and the hairs on the posterior corners of abdominal segments 3-6 are modified into short spines.

To this genus belong the mosquitoes that transmit malaria to human beings, and all except two (*A. georgianus* and *A. perplexens*) of the species listed for the Southeastern States have been proved susceptible to infection with the parasites of this disease. *Anopheles quadrimaculatus* was by far the most important species concerned in the transmission of the disease in the southeastern region. The others either are too rare, or their blood-feeding habits are such that they are considered to be of little importance as carriers. These conclusions are based on the fact that malaria infection in this region was almost invariably found associated with *quadrimaculatus.*

A. crucians is prevalent along the coastal plains and in the lower Mississippi Valley, and since specimens have been found infected in nature, the species cannot be eliminated entirely from consideration. Investigations several years ago in the Okefenokee swamp in southern Georgia (*220*) showed that malaria was absent in an area where *crucians* was prevalent and the only anopheline present. In Florida the malaria rate formerly was high in the northwestern part of the State, where *A. quadrimaculatus* predominates, but low in the southern half of the State, where *crucians* is abundant and the predominating species. Such malarious foci as were investigated in the southern part of the State have shown locally favorable conditions for *quadrimaculatus* breeding. Frequently the two species are found associated in the breeding places, but in general the occurrence of *quadrimaculatus* and the areas of high malaria endemicity in northern Florida and southern Georgia (*39*) appeared to be correlated with the presence of slightly alkaline surface waters, whereas *crucians* prefers water of an acid reaction, as found more generally in the southern part of Florida. The findings of high percentages of *crucians* infected with parasites in South Carolina by Sabrosky *et al.* (*280*), Frohne *et al.* (*117*), and Atchley (*4*) would seem to indicate that *A. crucians* may have played a more positive role in malaria transmission in that region. However, it was pointed out that since these findings were made during a period of low human parasitemia, the parasites may not have been those of human malaria.

A critical review of the records on infection of southern species and their role in malaria transmission was given by Barber and co-workers (*15*) in 1927, and more recently Boyd (*36*) has pro-

vided a summary of such information for the anophelines of the world.

Genus *Anopheles* includes most of the species of tribe Anophelini in the world but there are two other small genera—*Chagasia,* found in tropical America, and *Bironella,* in tropical Australasia. All of our species are placed in subgenus *Anopheles* except *A. albimanus,* which belongs to subgenus *Nyssorhynchus* Blanch. King and Bradley (*190, 191*), Freeborn (*115*), and Carpenter and LaCasse (*68*) have given reviews of the classification and distribution of the Nearctic species.

In the brief description of the adults under each species, distinguishing characters in the male terminalia are added for the species having the wing scales all dark, as specimens of these are by the male terminalia.

typically marked. Roth (*271*) has published detailed keys with illustrations to identify the *Anopheles* of the Southeastern States sometimes difficult to identify otherwise when rubbed or not

KEY TO SPECIES

ADULTS

1. Wings with spots or areas of white scales 2
   Wings entirely dark-scaled 6
2. Tarsi with conspicuous white bands or rings ..... *albimanus*
   Tarsi all dark 3
3. Costa dark except at extreme tip of wing (pl. 8, *A*); anal vein with three dark spots separated by white (two dark spots in male). Three species that are indistinguishable as adults except for about half of the specimens of *bradleyi* in which the stem of vein 5 is white-scaled instead of all dark as in the other two species ..... *crucians, georgianus, bradleyi*
   Costa with a white spot, usually prominent, at outer third, opposite the tip of the subcostal vein (pl. 8, *C* and *D*); anal vein with one or two dark spots or lines 4
4. Palpi with white rings; veins 3 and 5 with long areas of white centrally ..... *pseudopunctipennis*
   Palpi all dark; veins 3 and 5 entirely dark-scaled 5
5. Costal white spot prominent, nearly equal in length to the black-scaled area beyond it ..... *punctipennis*
   Costal spot much reduced, usually less than a third as long as the subapical black-scaled area, sometimes lacking; other white spots on wing also reduced, especially on stem of vein 4. A species closely related to the above, which can be identified positively by the morphology of the egg (see the descriptions of the two species) ..... *perplexens*
6. (1) Wings unspotted; mesonotal bristles unusually long, about one-half the width of scutum; palpi entirely dark. A very small species breeding in tree holes ..... *barberi*
   Wings with dark spots, more or less distinct; mesonotal bristles mostly shorter than one-half width of thorax 7
7. Palpi entirely dark; wing spots distinct; small knee spots present; frontal tuft of occiput with some of the hairs pale, a median patch of pale scales at vertex; processes of ninth tergite of male stout, rounded, and usually expanded at tip ..... *quadrimaculatus*
   Palpi with white rings, or knee spots lacking; wing spots usually indistinct; frontal tuft all dark; processes of ninth tergite slender, pointed 8
8. Palpi usually distinctly ringed at apex of each segment; occiput with a patch of pale scales at vertex; knob of halter pale-scaled; knee spots present: phallosome with the preapical pair of leaflets more than half as long as the apical pair. Breeds in fresh water ..... *walkeri*

Palpi with faint white rings on apical segments or entirely dark; occiput entirely dark-scaled; knob of halter dark-scaled; knee spots absent; phallosome with the preapical pair of leaflets no more than half the length of the apical pair. Breeds in salt water ..... *atropos*

LARVAE (FOURTH INSTAR)

1. Abdomen with plumose lateral hairs on segments 1 to 6, the branches short and sparse; frontal head hairs (Nos. 5-7) minute, single ..... *barberi*
   Abdomen with plumose lateral hairs on first three segments only; head with large plumose frontal hairs (fig. 13) 2
2. All clypeal hairs simple, inner pair well separated; postspiracular plate with a slender pointed tail on each side from posterior margin ..... *pseudopunctipennis*
   Outer clypeal hairs branched; postspiracular plate without tails 3
3. Outer clypeal hairs sparsely feathered or with a few (not over 10) short branches; inner clypeals usually sparsely feathered .. 4
   Outer clypeal hairs thickly branched, the branching dichotomous; inner clypeals simple (except in *walkeri*) or occasionally forked or branched 5
4. Inner clypeal hairs closely approximated; lateral hairs on abdominal segments 4 and 5 branched, usually triple ..... *atropos*
   Inner clypeal hairs widely separated (by about one-third the distance between the outer clypeals); lateral hairs on segments 4 and 5 single ..... *albimanus*
5. Abdominal segments with two conspicuous hair tufts (hairs 2 and 0) anterior to palmate hair; these hairs usually approximately equal in size and with four to nine branches on segments 4 and 5 ..... *crucians*
   Hair 0 undeveloped or very much smaller than hair 2, the latter usually single or double, but sometimes with three to six branches on segments 4 and 5 6
6. Sutural head hairs (Nos. 8 and 9) large, usually with 8 to 10 branches; basal tubercles of inner clypeal hairs separated by more than the diameter of one tubercle; palmate hair frequently partially developed and functional on segment 2 .... *quadrimaculatus*
   Sutural hairs with two to six branches or the basal tubercles of inner clypeals usually separated by less than their diameter (variable in *bradleyi*); palmate hairs rudimentary on segment 2 (except in *walkeri*) 7
7. Inner clypeal hairs with sparse, minute feathering toward tip; hair 1 of prothorax with three to five branches from near base; palmate hairs partially developed on segments 1 and 2 ..... *walkeri*
   Inner clypeal hairs usually simple (rarely forked or with two or three branches toward tip); hair 1 of prothorax short, usually single or weakly branched toward tip (frequently with some branches before middle in *punctipennis*); palmate hairs rudimentary on segments 1 and 2 8
8. Only three pairs of functional palmate hairs (segments 4 to 6); hair 5 of segment 1 usually with five to seven branches, arising irregularly along the stem ..... *georgianus*
   Five pairs of functional palmate hairs (segments 3 to 7); hair 5 of segment 1 usually with three to five branches from near base 9
9. Leaflets of palmate hairs on segments 3 and 7 usually somewhat smaller than those on 4 to 6 and mostly with smooth margins, especially on segment 7; hair 5 of segment 1 about twice as long as hair 4 and usually four- or five-branched ..... *bradleyi*
   Palmates on segments 3 and 7 about equal in size to the others, with broad leaflets, most of which have serrated margins; hair 5 of segment 1 about of same length as hair 4, and usually three- or four-branched. Two species with very similar larvae, which can usually be identified, at least in a series, by the number of branches of the antepalmate hair (hair 2) on segments 4 and 5 as follows:
   Hair 2 usually with two to four branches, rarely with one or two of the four hairs single ..... *punctipennis*

Hair 2 usually all single, or with no more than two of the four hairs on segments 4 and 5 two-branched before the middle, rarely with three or all four, branched before middle ..... *perplexens*

ANOPHELES ALBIMANUS Wied.

(Syn., *A. albipes* Theob.)

This species is the only anopheline included here in which the tarsi are white-banded. It is a tropical species, of much importance as a vector of malaria in tropical America. It was introduced into Key West, Fla., in 1904, and apparently developed one brood there before being eradicated, according to the records of its discoverer, George N. MacDonell. This event and the possibility that the species might become established in southern Florida and along the Gulf Coast were discussed by King (*184*). During and after World War II, *albimanus* was again discovered in southern Florida, with collections being reported from the Keys, (*132, 253*), one adult from as far north as West Palm Beach (*323*), and one larva from Boca Raton (*66*). Pritchard *et al.* (*253*) reported finding a single larval specimen on Big Pine Key in January 1946 and discussed the possibility that the species may be endemic in southern Florida, maintaining itself in limited numbers and locations. This appears to be the situation, for Haeger (*133, 134*) has reported the collection of larvae and adults at intervals during the years 1946-1950 while making intensive studies on the Keys. He found continuous breeding on Big Pine Key from October 1947 through December 1948, and the numbers of specimens sometimes were fairly large. The maximum light-trap collection for one night was 110 specimens, taken in early September. A few additional captures on the Keys from 1951 to 1957 are reported by Branch *et al.* (*53*). *Albimanus* is known to occur also along the Rio Grande River in the extreme southern tip of Texas, and was taken in light-trap collections in November 1945 at Corpus Christi, 150 miles to the north, by Eads (*99*).

The larvae of *albimanus* occur in open sunlit lakes and ponds of fresh or brackish water amongst mats of algae and other aquatic vegetation. They may be found also in a wide variety of temporary collections of water such as occur in hoof prints, wheel ruts, and artificial containers. The adults are strong fliers; the females feed readily on man and domestic animals. They enter dwellings during the night to bite but leave at dawn for forested areas to spend the daytime.

ADULT.—Proboscis dark, palpi with the apical segment (segment 5) all white, and segments 2 and 3 white-tipped. Occiput with a median area of white scales, dark ones laterally. Mesonotum clothed almost entirely with fairly broad, palish scales, extending on to scutellum. Wing costa with five or six white spots, some broad, and the other veins with numerous alternating black and white spots. Hind tarsi with segments 3 and 4 and apical half of segment 2 entirely white, the apical half of 5 also white, the base dark; fore and mid tarsi with the first two or three segments white-tipped, the others all dark. Abdominal tergites with fairly broad, pale scales through the central area, dark hairs or bristles laterally.

LARVA.—Antennal hair very small, split toward tip with two or three branches. Outer clypeal hairs single, and both the outer and inner clypeal hairs sparsely feathered or barbed, the inner hairs well separated, their bases being spaced nearly a third of the total distance between the outer clypeals. Post clypeals short, forked toward tip. Palmate hairs developed

on abdominal segments 1 to 7, sometimes on the metathorax also; leaflets long, slender, and with smooth margins. Hair 0 small, branched. Antepalmate hair 2 single on segments 4 and 5. Lateral hairs plumose on segments 1 to 3, single on segments 4 and 5.

ANOPHELES ATROPOS D. and K.

Little is known of the habits of this species except that it breeds in the salt water of coastal marshes from New Jersey southward to Texas. In southern Louisiana, Mississippi, and Florida adult females have been taken while biting in the open during the day, even in direct sunlight (*132, 151, 205*). In Florida, adults were once noted on an open marsh during the day and were encountered in large numbers after dark in two other localities. Adults have been taken in light traps in several localities on the coast.

Larvae were taken by Griffitts (*132*) in water ranging from 3 to 12 percent "salinity" (about 0.8 to 3.4 percent of salt), by Hinman (*151*) in water containing 0.8 to 1.85 percent of salt, and by the writers, in Florida, in water containing more than 1 percent of salt. Although the larvae of *atropos* and *bradleyi* have occasionally been taken together, the latter usually occurs in water of a lower salt content.

Anopheles atropos has been infected experimentally with malaria parasites (*221*), but it is of doubtful importance as a transmitter of the disease. Flights of a mile or so have been observed.

ADULT.—This species is almost entirely dark-scaled. Apical segments of the palpi faintly tipped with white or all dark. Occiput entirely dark-scaled. Bristles of the mesonotum of normal length, less than half the width of the mesonotum. Wing about 4 mm. long, usually with three or four spots slightly darker than the rest of the scaling (pl. 8, *F*). Knob of the halter dark-scaled. Abdomen and tarsi all dark. Femoral knee spots usually absent. The female differs from *A. walkeri* in having less distinct rings on the palpi and somewhat less distinct spots on the wing, the occiput and halter knob all dark, and femoral knee spots absent. It differs from *quadrimaculatus* in its smaller size, presence of palpal rings, dark occiput, much less distinct wing spots, and absence of knee spots. *A. barberi* is much smaller in size, has abnormally long thoracic bristles, entirely dark palpi, and no indication of dark spots on the wing. In the male there are three or four pairs of leaflets on the phallosome, the apical pair being twice as long as the next pair, which distinguishes it from *walkeri*. The lobes of the ninth tergite are bluntly pointed and much more slender than in *A. quadrimaculatus*.

LARVA.—Antennal hair small, divided into several branches toward tip, inserted at about the basal fourth of antennal shaft. Inner clypeals long, usually sparsely feathered toward tip, rarely simple, set close together, their basal tubercles separated by about the diameter of one; outer clypeals not more than half the length of the inner, with four to ten, rarely two or three, small branches toward tip. Post clypeals short, usually forked at tip. Frontal head hairs large, plumose. Inner and outer sutural hairs single or forked beyond middle. Hair 1 of prothorax small, single. Hair 0 on abdominal segments minute. Palmate hairs well developed on segments 4 to 7 and partly developed on 3, the leaflets with notched or serrated edges on apical half. Antepalmate hair (hair 2) single on segments 4 and 5. Lateral hairs on segments 1 to 3 plumose, those on 4 and 5 usually three-branched.

ANOPHELES BARBERI Coq.

The species occurs throughout the eastern United States from New York southward and westward to Texas and Iowa, and has been reported from all of the Southeastern States. Its habits and distribution have been summarized by Jenkins and Carpenter (*174*). It is never abundant nor found far from its breeding places.

The larvae are found principally in tree holes, although the writers once took them in wooden tubs at Mound, La., and they have been reported since from other artificial water containers. Larvae may be found in the breding places throughout the year. Matheson (*213*) states that the species hibernates in the north as second-stage larvae frozen solidly in ice. The larvae frequently are associated with *Aedes triseriatus, Orthopodomyia signifera,* and *Toxorhynchites* sp. The adult is very small, with unspotted wings, and is rarely encountered. Adults are to be found resting during the day above the water in tree holes where larvae occur and also in buildings and other shelters nearby. Thibault (*303*) in Arkansas noted that it enters dwellings readily and is a persistent biter, although easily disturbed. Both sexes are attracted to lights and often are found in light-trap collections. It has been proved susceptible to infection with malaria parasites (*300*), but is of doubtful importance in malaria transmission because of its limited occurrence and association with man.

ADULT.—This species is a small, completely dark, unmarked anopheline. Wing length about 3 mm. Knob of halter dark-scaled, wings without dark spots (pl. 8, *H*). In the male, the phallosome is without leaflets, which distinguishes it from all other anophelines in the United States except *A. albimanus.*

LARVA.—Antennal hair small, single, inserted near middle of shaft. Inner and outer clypeals single, the inner widely separated, closer to the outer than to each other. Post clypeals usually single, longer than outer, and more widely spaced. Frontal hairs small, simple, an unusual character in anophelines. Sutural hairs also single. Hair 0 on abdomen minute, unbranched; antepalmate hair on segments 4 and 5 branched toward tip, and inserted at side of palmate hair instead of in front; palmate hairs well developed on segments 2 to 7, the margin of the leaflets serrated; lateral hairs plumose on segments 1 to 6, the branches short and sparse.

ANOPHELES BRADLEYI King

(Syn., *A. crucians* var. *bradleyi* King: *A. crucians,* coastal or salt-water form)

Prior to 1939, when this species was first named, it was known as the "coastal variety" of *Anopheles crucians* (*44*). It occurs along the Atlantic and Gulf Coasts from Massachusetts south to Texas and Mexico. Because *bradleyi* adults can hardly be distinguished from those of *crucians* and *georgianus,* little is known of their specific habits. Reared specimens have been infected experimentally with *falciparum* malaria (*38*).

A. bradleyi larvae have been found principally in brackish water near the coast, and water with a low concentration of salt (about 1.5 percent or less) appears to be preferred. They have been taken with *Anopheles atropos* at the higher concentration and with the typical *crucians* when the water was nearly fresh. The larvae were first collected in Florida near the Saint Johns River in Brevard County in large roadside ditches having profuse growths of *Chara* and other aquatic plants, and have been found there repeatedly upon subsequent examinations. Elsewhere they have been collected in salt-marsh pools containing flotage, algae, and grasses. In Maryland, Vogt (*314*) reported that in the summer months the larvae were distributed, without regard to salinity, in locations having emergent vegetation of appreciable height. During the cooler weather of spring and fall they occurred in

water having submerged growths of pond weeds and algae but devoid of emergent vegetation. He attributed this to surface water temperatures, which may have been too high for the larvae in open waters in the summertime.

ADULT.—*Anopheles bradleyi* is one of the three members of the *crucians* series that are recognized by the ringed palpi and black and white spotted wings, but with the costa dark. The adults are difficult or impossible to distinguish from *A. crucians* and *A. georgianus*, except in specimens that have the stem of wing vein 5 entirely or mostly white-scaled. This condition has been found to occur in about half of the specimens examined. The male terminalia of the three species also are very similar.

LARVA.—Antennal hair branched several times from near middle. Inner clypeals fairly close together, the tubercles usually separated by about their own diameter or less, sometimes more (about 25 percent according to Miles (*229*)). Outer clypeals widely separated, thickly branched. Postclypeals very short, usually single, occasionally double, rarely three or four. Sutural hairs long, with two to six branches, the outer hair (No. 9) usually with three to five branches from near the middle, longer than inner, reaching base of frontal hair. Prothoracic hair 1 of thorax single or with up to five weak branches at tip. Hair 0 on abdominal segments small, unbranched. Palmate hairs developed and functional on segments 3 to 7, those on segments 3 and 7 somewhat smaller than the others and the leaflets mostly slender, with smooth margins, especially on segment 7. Antepalmate hair on segments 4 and 5 single, double, or triple (about 50 percent single in the series reported by Miles (*229*)). Hair 5 of abdominal segment 1 about twice as long as hair 4 and usually four- or five-branched (86 percent). Lateral hairs on segments 4 and 5 usually triple, with a fairly long stalk before point of branching. The larval characters most nearly resemble those of *A. punctipennis* from which it usually can be separated by the relative size and shape of the leaflets of the palmate hairs. The relative lengths of hair 5 of abdominal segment 1 and the number of branches of the antepalmate hairs are frequently of assistance for confirmation.

ANOPHELES CRUCIANS Wied.

The *crucians* group is now known to include three closely related species which are very similar in the adult stage but differ in larval and pupal characters. Two of these, *bradleyi* and *georgianus*, were described by King in 1939 (*185*) as varieties of *Anopheles crucians*, but it is believed that all three represent distinct species. The principal recognition characters for the adults are the white-spotted wings with three dark spots on the anal vein (two in the male), and dark-scaled front margin of the wing (pl. 8, *A*). The palpi are ringed with white. When resting, the adults hold the body at an angle of almost 90° with the resting surface, and in the Southeastern States may be distinguished from other anophelines in shelters by this characteristic.

Anopheles crucians is the common fresh-water form in the Southeastern States. In low coastal-plains areas it is frequently the predominating anopheline, but elsewhere is usually limited in abundance and distribution. Its range extends up the Atlantic Coast to Massachusetts and westward into southern Illinois, central Oklahoma, and Texas, with an isolated occurrence in the Pecos Valley, New Mexico (*191*). It also occurs on the east coast of Mexico and in some parts of the Caribbean region. *Crucians* larvae develop in acid waters, but often are found also with larvae of *quadrimaculatus* in the alkaline waters of lakes, ponds, pools, and swamps of a permanent or temporary nature, where aquatic vegetation or debris provides harborage. Freeborn (*115*) states that they also occur in wheel ruts, temporary pools in pine

barrens, and other non-vegetated water accumulations in which *quadrimaculatus* rarely would be found.

Although this species is susceptible to infection with malaria parasites, it is not known to be of serious importance in the transmission of malaria; in fact, the evidence points to the contrary, as pointed out in the generic discussion. Its virus potential for eastern equine encephalitis was rated as "poor" in tests by Chamberlain, *et al.* (*72*), but the virus of this type was recovered from a pool of wild-caught *crucians* in Louisiana and another in Georgia (*176, 196*). The species frequently bites out-of-doors at night or even during the day in the woods. The adults also enter houses, but at Mound, La., they were always found in a much smaller percentage of the total numbers present in the area than was the case with *Anopheles quadrimaculatus*. Also in the vicinity of Lake Apopka in central Florida, where *crucians* becomes extremely abundant, the number taken out-of-doors at night while attempting to bite was repeatedly very small in comparison with the total numbers present, as indicated by light-trap collections.

Observations made by the senior author in New Orleans indicate that this species may migrate for several miles when an unusual abundance occurs. MacCreary and Stearns (*209*) obtained specimens at two light-houses in Delaware Bay, one 3.2 miles from the nearest shore and the other 5.5 miles. Since both these localities are near the coast, it is not certain whether the species represented was *crucians* or *bradleyi*.

ADULT.—Proboscis dark. Palpi with the apical segment all white, segment 4 with narrow white rings at base and apex, and segment 3 usually with a few white scales at apex. Occiput with white narrow-curved scales and upright forked ones on vertex. Mesonotum with a grayish appearance and two darker submedian longitudinal stripes. Wing length about 4 mm.; costa and subcosta all dark, the other veins with alternating black and white spots, and the wing tip with a wide pale fringe spot; anal vein (vein 6) with three dark spots separated by white. Knob of halter dark. Tarsi all dark. In the male there are only two dark spots on the anal vein. The spines on the male claspette of the three species in this group differ slightly in number and shape (*185*), but their variations overlap and seem of doubtful use for identifying single specimens, although they may be of some use in a series.

LARVA.—The larva of *crucians* is distinguished from all other American *Anopheles* by the fact that the anterior submedian hair (hair 0) is well developed on several of the abdominal segments and the antepalmate hair on segments 4 and 5 is also multiple-branched. Antennal hair with several branches along the stem, inserted near basal fourth of shaft. Inner clypeals simple (occasionally forked beyond middle), closely approximated, their bases separated by less than the diameter of a basal tubercle; outer clypeals densely branched; post-clypeals short, single, or bifid distally. Sutural hairs fairly large with several branches along stem beginning near base. Palmate hairs well developed on segments 3 to 7, those on 3 and 7 about equal to the others or slightly smaller; the margins of the leaflets serrate. Hair 0 well developed with four to nine branches on segments 4 and 5 and about equal in size to the antepalmate hair. Lateral hairs on segments 4 and 5 with several branches beginning about the basal fourth.

ANOPHELES GEORGIANUS King

(Syn., *A. crucians* var. *georgianus* King)

This species was first collected by Bellamy (*22*) in 1937 from fresh-water breeding places in southern Georgia, and was described by King (*185*) as a variety of *Anopheles crucians*. The spots on the wings appear to be more contrasting than in *crucians*, but no

positive characters have been found for separating the adults, and nothing is known of their habits. The larva is unusual in that only three pairs of functional palmate hairs are present (on segments 4 to 6), whereas *crucians* and all the other species of *Anopheles* have at least five. Slight differences in the claspette spines of the male genitalia were described by King (*185*), with *crucians* intermediate in these characters.

Anopheles georgianus has been collected by Bellamy (*22*) in Brooks, Sumter, Terrell, and Thomas Counties, Ga. A single larvae was identified from a collection of *crucians* from a pond near Hinesville, Ga., in March 1941. It has since been reported from all the Southeastern States except Tennessee and Arkansas. Its typical habitat appears to be shallow collections of water in seepage areas at the heads of small streams, where the larvae usually occur in pure culture or with a small proportion of *crucians*. Wirth (*330*) collected the larvae in several localities in Louisiana, all in hillside seepage areas. They were found in small puddles, 4 to 30 inches in diameter, 2 to 4 inches deep, with algae and grassy edges. Michener (*225*) obtained the larvae in Mississippi in shallow water in spring-head areas with a low pH, usually with dead leaves and often with clumps of grass. Freeborn (*115*) reports that the presence of the small pitcher plant *Sarracenia purpurea* is often an index to the occurrence of *georgianus*.

ADULT.—This species belongs to the *crucians* group, or series, and appears indistinguishable except by larval characters. The description of the adult of *A. crucians* may therefore be referred to.

LARVA.—Hair 0 undeveloped, being minute and unbranched, which distinguishes it immediately from *crucians*. There are only three pairs of functional palmate hairs, on segments 4 to 6, which is quite exceptional among all anophelines. Miles (*229*) has shown the variations in the chaetotaxy of a series of specimens, some of which are as follows: posterior clypeal hairs usually simple or forked, rarely with three or four branches; outer occipital hair with two to six branches, usually three to five, short, about equal in length to the inner hair; antepalmate hairs of segments 4 and 5 usually two- to three-branched, occasionally simple or four-branched; hair 5 of abdominal segment 1 with four to nine branches, usually five to seven, the branches arising irregularly along the stem.

ANOPHELES PERPLEXENS Ludlow

This species was placed as a synonym of *A. punctipennis* and regarded as an extreme melanistic variant (*163*). A study of specimen material from southern Georgia and elsewhere by Bellamy (*23*), however, has shown that, in addition to the reduced white scaling on the wings described by Ludlow, and reduced branching of the larval antepalmate hairs previously noted by King *et al.* (*193*), the ova of the two forms were "strikingly different." He therefore considered it to be a valid species and this is concurred in by Drs. Alan Stone and K. L. Knight (personal communication).

Nothing is known of the blood-feeding or resting habits of *perplexens*, or its relation to the transmission of malaria. Its breeding places were found by Bellamy to be restricted principally to limestone springs and the margins of streams flowing from them. This type of breeding place had previously been noted by King *et al.* (*193*) for the melanistic form in central Florida. Seepage from an outcrop near Gainesville, Fla., where larvae were

collected, was probably through a limestone formation. Since then the Florida State Board of Health has accumulated records of this melanistic form (based on the reduced costal spot) from a number of other counties in north-central Florida. Bellamy's study material came mostly from Baker and Calhoun Counties in southern Georgia and included some material from other Georgia counties, and from a few other States. Russell (*279*) reported four reared adults with repressed costal spots, on two of which the spot was completely repressed. The exact locality for these specimens was not given, but they came from a series collected mostly in Lee County, Ga., with a few specimens from Sumter County, Ga., and Covington County, Ala. Roth (*272*) mentioned the occurrence of melanistic adults and larvae with single antepalmate hairs at Paris, Tenn., and Swannanoa, N. C. The female specimen from which *perplexens* was originally described came from Camp Roosevelt at Mount Gretna, Pa.

ADULT.—This species is generally darker than *punctipennis*. Wing length about 4 mm.; white spots on costa opposite the tip of the subcostal vein short, typically not more than a fourth or fifth as long as the subapical dark spot adjoining it, sometimes reduced to a few white scales or entirely dark. The mean of measurements by Bellamy (*23*) of this spot gave a ratio to the total length of the wing of about 0.055, compared with a ratio of about 0.11 for *punctipennis*, or averaging about half as long. The range of ratios was not given but it is presumed that there was overlapping. The costal spot in *punctipennis* is usually about one-half or more as long as the subapical dark spot, and much longer than the apical white spot. In the type female of *perplexens* the costal spot is about one-fifth as long as the sub-apical dark spot, and about equal in length to the subapical white spot. The costal white spot does not extend onto vein 1, white spots are lacking or very indistinct on the forks of vein 2, white spots are present on the forks of vein 4, about one-third as long as the forks, and the stem of vein 4 is apparently all dark-scaled. Of the present authors' collections from central Florida, one specimen has the costal spot completely suppressed, and on one other the scales on the forward edge of the costa are all dark but with a few indistinctly pale scales behind. There are four specimens in which the costal spot is of about the same width as in the type, and the other spots are similar to that specimen. Other specimens have wider costal spots but are possibly the same form. Measurements of the four specimens mentioned above gave ratios of the costal white spot to the subapical dark spot of 0.25, 0.20, 0.22, and 0.20. The ratios of some of the other specimens were: 0.39, 0.30, 0.30, 0.31, 0.36. Measurements of a few typical *punctipennis* from North Carolina, Illinois, and Massachusetts gave ratios of 0.43, 0.55, 0.40, 0.46, and 0.58.

The difference in the eggs, as described by Bellamy, was chiefly in the width and shape of the exposed exochorion dorsally between the floats. The *punctipennis* egg has a smooth-edged, elongate, oval- or slipper-shaped exposure, narrowest in the middle and continuous, with a high even frill. The *perplexens* egg has a much narrower area of exposed exochorion, the frill is low and follows the wavy, irregular course of the edge of the exochorion. Measurements gave a mean ratio of the width at the narrowest point to total egg length of 0.104, ranging from 0.092 to 0.109 for *punctipennis;* and 0.049, with a range of 0.035 to 0.061 for *perplexens*. Photographs of the two kinds of eggs showed them to be easily recognizable.

LARVA.—Almost identical with larva of *punctipennis* except in the branching of the antepalmate hairs of segments 4 and 5. Tabulations of the branching of these hairs in 1,620 specimens of each species (*23*) showed the following: In about 46 percent of *perplexens* all four of these hairs were single, and in an additional 40 percent, two or three of the four were single. In the rest, three or all four of the hairs were double. In *punctipennis* none of the specimens had all four of the hairs single and only 1 percent had two or three of them single. In about 3 percent one of the hairs was single, in 39 percent all four hairs were double, and in the rest some of the hairs were three- and four-branched. In these records, branching beyond the middle of the hair was disregarded. Based on these counts, it appears that larvae with all four hairs single can be identified with con-

fidence as *perplexens*, and those with two or three of the four hairs single are highly probables. Miles (*229*), in a study of the antepalmate hairs of *punctipennis* larvae, found a small proportion with these hairs single. He does not show whether all four were single in any specimens and, of course, it is possible that he had a few specimens of *perplexens* in his series. As previously mentioned, Roth (*272*) found several larvae with simple antepalmates in the same localities at Paris, Tenn., and Swannanoa, N. C., from which adults with repressed costal spots were taken.

ANOPHELES PSEUDOPUNCTIPENNIS Theob.

Anopheles pseudopunctipennis represents a complex of forms of which at least two, *A. pseudopunctipennis* and *A. franciscanus* McC., are represented in the fauna of the Southwest. The adults superficially resemble those of *A. punctipennis* but their white-banded palpi prevent confusion. *A. pseudopunctipennis* ranges northward from Argentina and Chile to Colorado and Kansas and eastward into the Mississippi Valley States of Missouri, Arkansas, Louisiana, Mississippi, and Tennessee. It is extremely rare in all these States and its habits in this area have not been observed. In other parts of its range the larvae occur in clear, sunlit pools containing algae, and along the vegetated margins of slow-flowing streams. The adults are said to enter houses and to bite man readily, although most feeding takes place out-of-doors on other animals. The species has been infected experimentally with both *vivax* and *falciparum* malaria, and has been found naturally infected in Argentina, Mexico, and Chile, where it is considered to be an important vector. Its importance as a vector in the United States has never been established.

ADULT.— Proboscis and tarsi dark, palpi ringed, and wings spotted. Palpi with the apical segment white except for a narrow black ring toward tip, segment 4 with a narrow white ring at base. Occiput with white scales at vertex. Integument of mesonotum with a broad median frosted stripe covered with yellowish-white scales. Knob of halter dark-scaled. Wing costa with a spot of white scales at the juncture of the subcostal vein and another at tip of wing; subcosta and vein 1 with a spot opposite the base of vein 2; veins 3 and 5 with long areas of white centrally; veins 2 and 4 also spotted; anal vein with the basal half white, the rest dark; fringe spots present at the tip of each vein. Tarsi and abdomen all dark.

LARVA.—Antennal hair small, single, attached near middle of shaft. Inner, outer, and postclypeal hairs all long, simple, the inner separated by more than the diameter of a basal tubercle. Sutural hairs large, with six or more branches along stem. Palmate hairs developed on segments 3 to 7, the leaflets with a few lateral serrations and tapered to a sharp point. Antepalmate hairs single on segments 4 and 5. Lateral hairs on segments 4 and 5 well branched. Postspiracular plate with a peculiar slender projection, or tail, on each side pointing backwards.

ANOPHELES PUNCTIPENNIS (Say)

(Syn., *Culex hyemalis* (Fitch))

Anopheles punctipennis is the most widely distributed anopheline in North America. It ranges from the Atlantic to the Pacific and from Canada to Mexico. The conspicuous white spot on the costa (pl. 8, *C*), combined with unbanded palpi, is the chief recognition character. It has a variety of breeding places. Throughout the southern range it occurs much more commonly late in the fall and early in the spring than in the summer, and seems to prefer the margins of flowing streams as breeding sites,

probably because of the lower water temperatures there (*13, 33, 287*). At Leesburg, Ga., the larvae were taken also in certain wells and deep lime sinks, and occasionally in containers (*268*). At Mound, La., where it was never abundant, it disappeared almost entirely during the warm months. In that vicinity pure cultures of the larvae were sometimes taken in the fall in small clay borrow pits or pools free of vegetation. As a rule the species is rare in central and southern Florida. Specimens of the melanistic form, *A. perplexens*, were previously reported (*193*) from Orange, Seminole, and Alachua Counties. *Perplexens* is now listed as a distinct species.

The females are active and bite principally at night, but will attack during the daytime in dense shade, or on cloudy days. Freeborn (*115*) states that *punctipennis* has been described as a "porch biter" and, although frequently taken in barns and other outhouses, it is seldom taken in homes. The species readily becomes infected with malaria parasites under experimental conditions, but it does not feed extensively on man in nature, and the epidemiological evidence indicates that it is not an important carrier of the disease. It has been proven an efficient host of the dog heartworm *Dirofilaria immitis* (*247, 336*).

ADULT.—Easily distinguished from *pseudopunctipennis* by the lack of white scaling on the palpi and on wing veins 3 and 5. Proboscis and palpi all dark. Occiput with white scales on vertex. Integument of mesonotum with a broad frosted median stripe covered with pale scales. Wing costa with a white spot at juncture of subcostal vein and at tip, the former about half as long as the subapical dark spot distal to it and continued over vein 1 and the stem of vein 2, the apical spot continued over the tip of vein 1; subcosta and vein 1 without a white spot opposite the base of vein 2, forks of veins 2 and 4 each with a white spot in middle, and the stem of 4 with several spots; veins 3 and 5 entirely dark-scaled. Anal vein with the apical half and the basal one-fourth or one-fifth dark, separated by white. Tarsi and abdomen all dark. The width of the costal spot as compared with that of *perplexens* is discussed under the latter species.

LARVA.—Antennal hair small, branched, inserted at about basal third of shaft. Inner clypeal hairs closely approximated, the basal tubercles nearly touching; outer clypeals densely branched; postclypeals small, usually single or forked at tip; sometimes three- or four-branched. Hair 1 of prothorax small, with several branches near or beyond the middle. Palmate hairs well developed on segments 3 to 7, nearly equal in size on all segments, and with the margin of the leaflets notched or serrated. Hair 0 minute on segments 4 and 5. Antepalmate hair on segment 4 and 5 usually double or triple, sometimes with one or two of the four hairs single, or four-branched. (See under *perplexens* for the percentages with different branching.) Lateral hairs on segments 4 and 5 with the branches all arising from the same point.

ANOPHELES QUADRIMACULATUS Say

(Syn., *A. annulimanus* V. d. W.; the common malaria mosquito)

Anopheles quadrimaculatus is a fairly large mosquito, dark brown in color, with four darker spots near the center of the wing field (pl. 8, *G*). In its resting position the angle at which the body is held is not so pronounced as with some of the other species, and the position of specimens heavy with blood may not appear characteristic.

This species is active principally at night, although during the cooler months the females will seek blood meals in the daylight on warm days, in dwellings, or in the woods. The daily flight or dispersal period begins just at dusk and continues for half an

hour or so. During the remainder of the night, flight is probably limited for the most part to local forays in search of a host. Another period of activity begins just at daylight and ends with a general shift to the daytime resting places. The flight range of *quadrimaculatus* from the breeding places undoubtedly varies a good deal, probably depending largely upon the numbers produced and the proximity of blood meals. Although flights up to 4 miles and over have been recorded for the species, few individuals reach such distances, and in planning control operations the maximum effective flight range may be taken as about 1 mile or less under average conditions during the summer. Control over such restricted areas proved highly successful in preventing malaria transmission in areas of military importance in this country during World War II.

Although little is known of the extent to which this species feeds upon wild animals, man and most of the domestic animals are known to be attacked by the blood-hungry females. Information on the relative attractiveness of different hosts was obtained in a series of cage experiments conducted in Baltimore, Md. (*58, 59*). Two host animals were exposed side by side to the bites of *quadrimaculatus* females, which were afterwards collected and the blood meals identified by the precipitin test. Among cattle and horses it was found that the attractiveness varied more between individuals than between the species, and that a decided variation occurred between individuals of the human race. The man received, on an average, about one-sixth as many bites as the horse or cow. Sheep, goats, dogs, and pigs appeared to be less attractive, in the order given, while rabbits and chickens proved to be very poor hosts even in the absence of other animals.

To determine the proportion of mosquitoes that obtained blood meals from different hosts under natural conditions, a large series of records had previously been obtained at Mound, La., by testing the blood from freshly fed females collected from the tenant dwellings and outbuildings on three plantations (*194*). From a general series of collections during the mosquito season of 1922, 38 percent of the specimens taken inside the house, and about 2 percent of those from underneath the house and in the outbuildings were found to have fed on man. The weighted average was 4.3 percent for the entire *quadrimaculatus* (female) population, being 6 to 8 percent when the average number of females per location was about 200 to 500 and decreasing to 3 percent or less when the average reached 1,500 or more. The average percentages for the other hosts for which blood tests were made were as follows: Cow, 36; horse, 33; pig, 16; dog, 8; and other animals (chicken and cat), 3.

Although very high malaria infection rates (10 percent or even more) have been found among anophelines in other countries, the percentage of infected *quadrimaculatus* in malarious areas in this country appeared to be comparatively low, probably much lower than is generally supposed. From an examination of 9,340 specimens collected on plantations in the vicinity of Mound, La., in 1922 (*182*), only 10 were found to contain the sporozoite form of the parasite in the salivary glands and therefore to be capable of transmitting the infection at the time of capture. This gave

a sporozoite rate of 0.107 percent, or approximately 1 infective specimen per 1,000. The annual malarial rate in humans on the same plantations during that year was about 45 cases per 100. At Edenton, N.C., a gland-infection rate of 0.33 percent was obtained from dissections of 1,486 mosquitoes over a period of 3 years (*35*).

Quadrimaculatus breeds chiefly in permanent, fresh-water pools, ponds, and swamps that contain aquatic vegetation or floating debris (pl. 5). The larvae feed almost entirely at the water surface, and since they seem to make no selection of material, provided it is small enough to be ingested, the food consists of the general variety of small organisms and detritus found at the water surface. From a large series of observations at Mound, La., where *quadrimaculatus* was the predominant anopheline, Bradley (*45*) reported that flagellates, diatoms, and green algae made up a large proportion of the plankton content of the surface layer in the natural waters of that area. The approximate average numbers of organisms per cubic centimeter in breeding places having more than one larva per dip were as follows for the breeding seasons of 1928 and 1929, respectively: total plankton, 8,600 and 6,300; flagellates, 5,400 and 4,200; diatoms, 1,800 and 500; green algae (other than flagellate forms), 700 and 900. Present in smaller numbers were the ciliates, blue-green algae, and amoeboid protozoa, although the first two were fairly abundant at times. The four principal genera among the flagellate forms were *Euglena, Chlamydomonas, Trachelomonas,* and *Phacus,* which composed about 75 percent of the total organisms in this class in the places of high larval density. The report of studies made by Boyd and Foot (*37*) shows a similar plankton content in the surface waters at Edenton. A classification of ponds in which the abundance of desmids is used as an index to the suitability of the water for specific anopheline breeding has been suggested by Frohne (*116*). At high summer temperatures, with an ample food supply, larval development under natural conditions may be completed in about 1 week, although some larvae develop more slowly than others under the same conditions. With a minimum of 3 or 4 days for the other aquatic stages (egg and pupa) and about 4 days for the preoviposition period, the minimum time for a complete generation would be 14 or 15 days. At low temperatures or with scanty food supply the developmental cycle is greatly prolonged.

This mosquito occurs throughout the Eastern, Southern, and Midwestern States to the Great Plains, and its range extends into southern Canada and Mexico. It is found in all of the Southeastern States and is the principal species concerned with malaria transmission in this region. Also, it has been proven to be an efficient host of the dog heartworm, *Dirofilaria immitis* (*247*). In laboratory experiments it failed to transmit the viruses of eastern and western equine encephalitis (*223*) and its vector potential for both types has been rated as "poor" (*72*).

ADULT.—Proboscis, palpi, thorax, and tarsi all dark-scaled. Occiput with a patch of pale scales at vertex. Wings all dark, with four distinct darker spots, one extending across the veins from the base of vein 3 to vein 5 at the junction of the posterior cross vein, one at the base of vein 2 and its junction with vein 1, and one each at the forks of veins 2 and 4. Knob of

halter dark-scaled. Small pale knee spots present at tips of femora. In the male the lobes or processes of the ninth tergite are stout, rounded, and usually slightly expanded at tip. This species is the largest of local anophelines, with a wing length of approximately 4.5 mm. compared with an average length of perhaps 4.0 mm. for most of the others, and 3.0 for *A. barberi*. Rubbed specimens are sometimes difficult to distinguish from *A. atropos* and *A. walkeri*.

LARVA.—Antenna with a large, well-branched tuft inserted near middle of shaft and its tip reaching the apical spine. Inner clypeal hairs usually simple (occasionally branched beyond middle), their bases separated by more than the diameter of one of the tubercles. Outer clypeals densely branched, the posterior clypeals very small, forked at tip. Sutural hairs comparatively large, with 8 to 10 branches along the main stem. Hair 1 of prothorax small, single. Palmate hairs well developed on segments 3 to 7, and frequently partially developed and functional on 2. Hair 0 rudimentary, antepalmate hairs usually single, and the lateral hairs multiple on segments 4 and 5.

ANOPHELES WALKERI Theob.

Females of *Anopheles walkeri* have narrow but distinct white rings on the palpi and white knee spots at the tips of the femora. The dark wing spots (pl. 8, *E*) are less pronounced than those of *A. quadrimaculatus*. Florida specimens are unusually dark. This species is widely distributed over the eastern half of the United States from southern Canada to the Gulf of Mexico. It has been recorded for all of the Southeastern States. Its principal breeding places are fresh water marshes containing luxuriant growths of such emergents as cutgrass and cattails, together with algae and other floating plants and debris (*8, 46, 175*). The larvae have been taken from ricefields and from sloughs covered with water hyacinth in Louisiana (*205*). A study of specimens from Florida has shown some larval characters distinct from those of specimens obtained in New York State (*46*). Matheson and Hurlbut (*215*) have since reported that both forms occur in the vicinity of Ithaca, N. Y. Specimens from each State have been infected experimentally with malaria parasites (*198, 214*), and one specimen infected with the parasites in nature has been reported from Bondurant, Ky., in the vicinity of Reelfoot Lake (*7*). Flights of from ½ to 2 miles from the nearest breeding place have been reported (*8*). The adults are readily attracted to light traps at night, and the females to human hosts both in the daytime and at night (*50, 82, 175*). The breeding places and the resting places of adults usually are difficult to locate (*7, 82, 175*). The adults seem to prefer to rest during the day on the emergent vegetation in the breeding areas although they also have been found in damp barns, spring houses, and under bridges (*8*). Matheson and Hurlbut (*215*) and Hurlbut (*170*) found that two distinct types of eggs were deposited by this species, "summer" and "winter" eggs, and they concluded that overwintering occurred, at least in the North, in the egg stage.

ADULT.—Proboscis all dark. Palpi usually distinctly white at tip and with narrow white rings at the apex of the other segments. Occiput with a small patch of white scales on vertex and some white hairs in frontal tuft. Mesonotum all dark. Wing length about 4 mm., all dark-scaled, with four dark spots where the scales are dense, the spots at the same location on the veins as those of *A. quadrimaculatus* but less distinct. Knob of halter pale-scaled, sometimes mostly dark, in the northern part of range (*297*). Tarsi dark, femora with small knee-spots. The female differs from *quadrimaculatus* in having white-ringed palpi, pale-scaled halter knob, less distinct wing spots,

and smaller size; and from *atropos* in having a patch of pale scales on the vertex of the occiput, pale-scaled halter knob, femoral knee-spots, more distinct palpal rings, and somewhat more distinct wing spots. In the male the preapical pair of leaflets of the phallosome are more than half the length of the apical pair, to distinguish it from *A. atropos*, while the lobes of the ninth tergite are longer and more slender than in *quadrimaculatus*.

LARVA.—Antennal hair fairly large and with several branches inserted before middle of shaft. Inner clypeal hairs with sparse minute feathering toward tip, the basal tubercles separated by about the diameter of one of the tubercles; outer clypeals densely branched; postclypeals minute, forked at tip. Sutural hairs comparatively small, with several branches. Hair 1 of prothorax with 3 to 5 strong branches from near base. Palmate hairs well developed on segments 3 to 7 and partially developed on 1 and 2. Hair 0 comparatively large on segments 1 to 7 with three to seven branches, but much shorter than hair 2 and much smaller than hair 0 on *bradleyi*. Antepalmate hair on segments 4 and 5 usually single, sometimes double. The larvae differ from those of *quadrimaculatus* and *atropos* in having the inner clypeal hair feathered, in the branching of hair 1 of the prothorax, in the size and branching of hair 0 of the abdominal segments, and in other details. The inner clypeals and hair 0 differ from most of the other species. A study of the chaetotaxy of the four instars has been published by Hurlbut (*169*).

Genus CULEX Linnaeus

The mosquitoes of this genus breed in more or less permanent collections of water. The eggs are laid on the surface of the water in rafts of a hundred or more (fig. 3, *A*), and hatch within two or three days at summer temperatures. Breeding is continuous during warm weather and even through the winter in warmer parts of the South. Elsewhere, inseminated females pass the winter in hibernation.

The female palpi are short, the male palpi longer than the proboscis; the male antennae bushy (fig. 1, *B* and *C*). All of our species except three have an unbanded proboscis and tarsi and are more or less difficult to identify except by the male terminalia or larvae. The scutellum of *Culex* is trilobed with separated tufts of setae, the second marginal cell of the wing is as long as or longer than the petiole; spiracular and postspiracular bristles are lacking; hairs are absent on the underside of the subcostal vein, and setae are absent at base of vein 1 above. The terminal segments of the female abdomen are only slightly tapered, if at all, and the tip has a blunt appearance in comparison with the pointed tip of *Aedes* and *Psorophora* (fig. 17). Segment 8 is short but visible externally, and the cerci are usually retracted and invisible.

In the males the basistyle has a large subapical lobe with various modified appendages, but lacks a basal lobe and claspettes. The apex of the tenth sternite bears a tuft of bristles, or a row of stout teeth. Other characters are given in the discussion of the subgenera.

The larvae of *Culex* are characterized chiefly by having from four to six or seven pairs of ventro-lateral hair tufts or single hairs on the air tube. In addition, the large antennal tuft in most of the species is set in a notch or constriction at about the distal third of the shaft, beyond which the shaft is distinctly more slender. *C. restuans* is the only one of the local species which lacks this constriction, and *Culiseta melanura* is the only species outside of genus *Culex* which has a similar constriction. The comb scales of *Culex* may be in either a single row or a large patch, the individual scale usually rounded and fringed with subequal

spinules, but sometimes long and pointed, with the fringe limited to the basal half. The anal segment is always ringed by the sclerotized plate, and the ventral brush is limited to the bared area.

Because of the difficulty of distinguishing the adults of some species of *Culex*, it is often convenient when identifying collections, particularly those taken in light traps, to use the two subgeneric names, *Culex* and *Melanoconion* Theob., into which 14 of the Southeastern species are divided, as follows: (*Culex*) *bahamensis, nigripalpus, p. pipiens, p. quinquefasciatus, restuans, salinarius, tarsalis;* (*Melanoconion*) *atratus, erraticus, iolambdis, mulrennani, opisthopus, peccator, pilosus.* The one remaining species, *territans*, is placed in subgenus *Neoculex* Dyar. The adults of subgenus *Melanoconion* are all of small size, with wing lengths usually from 2.5 to 3.0 mm. The lateral wing scales,[5] particularly

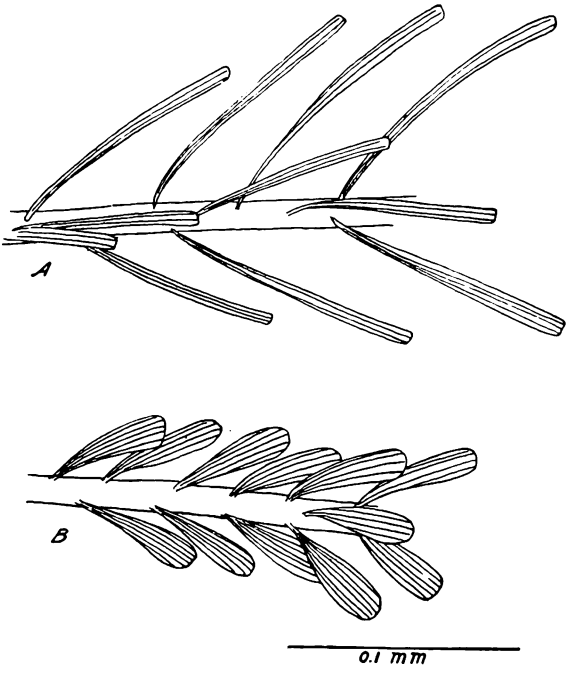


FIGURE 25.—Types of wing scales on forks of vein 2: *A*, *Culex* (*Culex*); *B*, *Culex* (*Melanoconion*).

on the forks of vein 2, are fairly short, broad, and dense (fig. 25, *B*), their length only about 2.5 to 3 times the breadth. The occiput has some broad, appressed, usually dingy or grayish scales, either in a large median patch, or a line around the eyes. In *erraticus* especially, the flat scales are often reduced to a single row border-

[5] There are two types of wing scales: one type broad and closely appressed to the veins (squamae scales); the other, standing out at an angle from the veins (lateral, or plume scales). The latter may be either long and slender, or short and more or less spatulate. The plume scales are on the upper surface of the wings on some veins and on the under surface on others.

ing the eyes and are difficult to see. The examination should be made at fairly high magnification and with good lighting. The dorsal flat scales should not be confused with the flat, whitish scales at each side of the head, which are present also in the other subgenera.

In male *Melanoconion* the dististyle is usually enlarged apically, and the subapical lobe of the basistyle has two subdivisions. The tenth sternite is comb-shaped apically, with a row of short, rounded teeth, and is bent inward nearly at right angles. The paired mesosomal plates are undivided and each has a long curved basal hook directed ventrally (lacking in *C. atratus*). The ninth tergite has paired lobes, the shape of which is usually quite distinctive in each species and therefore useful in identification. The Southeastern species are included in excellent taxonomic reviews of the subgenus by Rozeboom and Komp (*278*) and Foote (*114*). The former contains illustrations and keys to the male terminalia of all the species, while the latter does the same for the larvae and pupae. Foote has resurrected the subgenus *Mochlostyrax* to include *C. pilosus* and similar species in the American Tropics based on larval characters. Rozeboom and Komp, however, did not consider that the *Mochlostyrax* group warranted subgeneric rank, and included it only as a section of subgenus *Melanoconion* since the differences in the male genitalia are minor. We agree with this decision.

Subgenus *Culex* is generally larger in size, with wing lengths of about 3.5 to 4.0 mm. The lateral wing scales are long and slender (fig. 25, *A*) and the occiput is without broad appressed scales dorsally. The dististyle of the male in all our species is slender and moderately tapered from base to tip. The subapical lobe of the basistyle is undivided. The tenth sternite has a dense apical tuft of short bristles or slender spines and usually a long, stout, curved, basal arm or a short fingerlike projection. The paired plates of the mesosome usually have two more or less distinct arms, or divisions. The posterior lobes of the ninth tergite are broadly rounded, separated by a shallow indentation, and are of little value in identification.

In our single species of *Neoculex* the principal superficial distinguishing character is a narrow band of white scales at the apex of the abdominal segments, whereas the bands or lateral spots are basal in the other species. The wing scales are slender and the occiput is without broad scales dorsally, as in subgenus *Culex*. In the male the subapical lobe of the basistyle is not distinctively divided, the tenth sternite has a row of stout teeth, as in *Melanoconion*, but this portion is not so strongly bent; the mesosome lacks the basal hook, and the outer end of each mesosomal plate is studded with small tubercles.

A short key to all dark-legged species of *Culex* by the male terminalia has been included as an aid in their identification. In the larvae of subgenus *Culex* the upper and lower head hairs are multiple, with feathered branches, and about equal in length. The spines of the pecten usually have only a few coarse teeth on one side of the basal half. The apical bristle of the air tube is straight. In subgenus *Melanoconion* both the upper and lower head hairs are either single or double, simple or sparsely feathered, or the

upper may be multiple, but if so, it is much shorter than the lower. The pecten spines are finely fringed on one side from base to tip. The apical bristle of the air tube is strongly curved, or hooked, with one or two small teeth, or hooks, near its base. Our one species of *Neoculex* has both head hairs single like *Melanoconion* and a few coarse teeth on the pecten spines as in *Culex*. The apical spine of the air tube is straight.

KEY TO SPECIES[6]

ADULTS

1. Scales of wing long and slender (fig. 25, *A*); occiput without broad pale scales at vertex or around upper eye margin 2
   Wing scales short and moderately or distinctly broadened on forks of vein 2 (fig. 25, *B*); occiput with broad, pale or dusky, appressed scales, sometimes limited to a border along the eyes but nearly always extending to the vertex. (If the scales on the occiput are all narrow but the wing scales are dense and broadened, see *Culiseta melanura*). Small *Culex*, subgenus *Melanoconion* 8
2. Abdomen with narrow bands and lateral spots of white scales on posterior (apical) margin of the segments ..... Subgenus *Neoculex*, *territans*
   Abdomen with the white segmental bands or lateral spots basal Subgenus *Culex* 3
3. Proboscis and tarsi ringed with white, the tarsal segmental rings both basal and apical 4
   Proboscis and tarsi not white-ringed 5
4. Tarsal rings broad; femora and tibiae with longitudinal lines of white scales on the outer aspect; wings usually with a patch of white scales at base of costa ..... *tarsalis*
   Tarsal rings narrow, the apical banding usually limited to hind feet; femora and tibiae not lined; wing scales all dark. Florida Keys ..... *bahamensis*
5. Abdominal segments unbanded or with narrow basal pale bands .. 6
   Abdominal tergites with conspicuous basal bands of white scales. (If femora, tibiae, and wing costa are sprinkled with white, see *Culiseta inornata*) 7
6. Abdomen usually with a few yellowish or dingy white scales at the base of some of the segments, or with narrow basal bands; tips of segments sometimes slightly pale-scaled, and seventh segment frequently entirely yellowish-scaled; three or four groups of white scales on sides of thorax ..... *salinarius*
   Abdominal segments dark-scaled except for lateral basal white spots, usually visible from above on some segments; scaling on pleura frequently entirely lacking or, if present, usually limited to less than six scales in any group ..... *nigripalpus*
7. (5) Mesonotum usually with a pair, sometimes two pairs, of small white dots near the middle (fig. 19, *K*), and grayish scales around the margin; mesonotal vestiture mostly of fine, brownish, hairlike scales and with a smooth appearance. The white dotted *Culex* ..... *restuans*
   Mesonotum without white dots; mesonotal scales much coarser and grayish in color ..... *pipiens quinquefasciatus* *pipiens pipiens*
8. (1) Hind tarsi with very narrow apical and basal white rings on segments 1 to 4, segment 5 nearly all white. Southern Florida *opisthopus*
   Tarsi all dark 9
9. Occiput with a large median triangular area of narrow scales

[6] Characters for distinguishing the two species of *Culiseta* are included in this key in couplets 1 and 5, in view of the difficulty of separating the two genera in the generic key.

extending nearly to the vertex, the broad appressed scales usually reduced to a narrow line bordering the eyes; mesonotal scaling often markedly bronzy or golden; abdominal tergites frequently with complete basal white bands. Throughout the Southeast ..... *erraticus*

Occiput mostly covered with broad appressed scales, the narrow curved scales usually limited to a median line or small posterior triangular patch; mesonotal scales usually darker; abdominal tergites usually entirely dark-scaled or with small basal lateral or median white patches, seldom with slight basal bands .....
southern Florida: *atratus*
southern Florida: *iolambdis*
Florida Keys: *mulrennani*
throughout the Southeast: *peccator*
Southeastern Coastal States: *pilosus*

DARK-LEGGED CULEX BY MALE TERMINALIA

1. Tenth sternite with an apical tuft of short bristles or spines; subapical lobe of basistyle not divided ..... Subgenus *Culex* 2
   Tenth sternite comb-shaped apically, with a row of short, stout teeth 6
2. Subapical lobe of basistyle with eight appendages; base of tenth sternite produced laterally into a blunt point or a short, nearly straight arm 3
   Subapical lobe with five or six appendages; base of tenth sternite produced into a long, stout, strongly curved arm 4
3. Ventral arm of mesosomal plate long, ribbonlike, curved sharply outward toward basistyle at about the outer third and tapered to a point; dorsal arm slender, pointed, lying more or less parallel with inner margin of ventral arm and extending little if any beyond the curved shoulder of this arm..*pipiens quinquefasciatus*
   Ventral arm of mesosomal plate of same general shape as above but somewhat shorter; dorsal arm broader, semicylindrical in appearance, with a truncate, slightly upturned tip; this arm placed obliquely, usually extending to or toward tip of ventral arm ..... *pipiens pipiens*
4. Mesosomal plate with a short lateral arm and a longer posterior arm having a small tooth near base ..... *restuans*
   Mesosomal plate with two arms and a median row or group of four to seven short, stout teeth 5
5. Dorsal arm of mesosomal plate short, bent in middle at a right angle (thumblike), with a pointed tip; subapical lobe of basistyle with two setae, a leaflet, and three rods; spines of tenth sternite all sharp and pointed ..... *salinarius*
   Mesosomal plate with a stout, straight dorsal arm; lobe of basistyle with only one seta before the leaflet; spines on one side of tuft of tenth sternite short and bluntly rounded ..... *nigripalpus*
6. (1) Subapical lobe of basistyle not distinctly divided; mesosomal plate without a basal hook; outer end of mesosomal plate studded with small tubercles ..... Subgenus *Neoculex*, *territans*
   Subapical lobe of basistyle with distinct divisions; mesosomal plate with a long, curved basal arm or hook (except in *atratus*) .... Subgenus *Melanoconion* 7
7. Dististyle narrow, tapered to a slender tip; basistyle with one to six broad, curved filaments near base of basal division of subapical lobe; lobes of ninth tergite gourd-shaped ..... *atratus*
   Dististyle with the distal portion enlarged, snout-shaped; basistyle without accessory filaments 8
8. Subapical lobe of basistyle without a broadened leaflet 9
   Apical division of lobe with a broadened, striated leaflet, or a greatly expanded one 10
9. Lobes of 9th tergite irregularly ovate, closely approximated; the two arms of the basal division of subapical lobe of basistyle unequally divided ..... *iolambdis*
   Lobes of 9th tergite elongate, fingerlike projections, widely separated; arms of the basal division of subapical lobe of equal length ..... *opisthopus*

10. Distal half of dististyle greatly enlarged, quadrate in shape, with the upper margin hirsute and the apex upturned; lobes of the 9th tergite small, ovate ..... *peccator*
Dististyle moderately enlarged apically, rounded, cap-shaped or snout-shaped 11
11. Leaflet of subapical lobe greatly expanded, fanshaped, with a wrinkled surface, lobes of 9th tergite large, elliptical, diverging at an angle ..... *erraticus*
Leaflet of subapical lobe narrow, striated lengthwise, its length three or four times the width; lobes of 9th tergite otherwise 12
12. Lobes of 9th tergite represented by a pair of fingerlike projections from the posterior corners of a broad plate; inner, or ventral, margin of mesosome with two long, pointed teeth ..... *pilosus*
Lobes of 9th tergite semi-ovate, each with a lateral thumblike projection; inner margin of mesosome with a single short, stout tooth ..... *mulrennani*

LARVAE (FOURTH INSTAR)

1. Both upper and lower head hairs with three or more branches, long ..... Subgenus *Culex* 2
Lower head hair single or double; the upper usually much shorter and single, double, or multiple 7
2. Antenna rather short, of uniform shape, the hair tuft placed near middle; air tube with four to six long single hairs irregularly placed, and one pair of small subapical hairs, double or triple *restuans*
Hair tuft of antenna placed in a constriction near outer third, the part of shaft beyond the tuft more slender; hairs of air tube not as above 3
3. Only two anal gills, short and bulbous; air tube spinose .... *bahamensis*
Anal gills four, cylindrical; air tubes not spinose 4
4. Air tube with five pairs of long tufts in a nearly straight line *tarsalis*
Air tube with four or five pairs of tufts, the subapical pair laterally out of line (fig. 11); hair usually little if any longer than diameter of tube 5
5. Air tube about 4:1, the sides not parallel; lower head hairs usually with five or more branches .. *pipiens pipiens, pipiens quinquefasciatus*
Air tube 6:1 or 7:1, sides nearly parallel; head hairs usually with three or four branches 6
6. Thorax with fine spicules; hair 1 (inner submedian hair) of mesothorax very small, about equal in size to hair 2 ..... *nigripalpus*
Thorax glabrous; hair 1 of mesothorax much longer than hair 2 *salinarius*
7. (1) Pecten spines with only one to four coarse side teeth; air tube without subdorsal hair tufts; apical bristle of air tube straight ..... Subgenus *Neoculex*, *territans*
Pecten spines finely fringed on one side nearly to tip; air tube with one or more pairs (usually two or three) of small subdorsal hairs, double or triple; apical bristle of air tube strongly curved or hooked ..... Subgenus *Melanoconion* 8
8. Air tube short, about 3:1, with eight pairs of very long hair tufts, the proximal two inserted before the distal end of pecten; comb-scales 8 to 12 in an irregular row, the single scale long, thornlike, bare, or finely fringed toward base ..... *pilosus*
Air tube long and slender, 6:1 or more, with four to six pairs of ventral tufts beyond the pecten 9
9. Comb of eighth segment in a single or partially double row, the single scale long, thornlike, fringed on basal half; body of larva densely pilose ..... *erraticus*
Comb scales in a patch of several rows, the single scale rounded and fringed apically 10
10. Hair tufts of air tube long, the proximal pair about twice as long as the diameter of tube at the point of insertion, or longer, the branches finely feathered; upper head hair usually double or triple (usually single in *iolambdis*) ..... *peccator*
iolambdis
mulrennani

Hair tufts of air tube small, little if any longer than the diameter of tube at point of insertion; upper head hair five- to seven-branched 11

11. Lower lateral hair on abdominal segment 1 (hair 7) single; pecten teeth with fairly coarse side spinules; thorax and abdomen distinctly spicular ..... *atratus*

Lower lateral hair on segment 1 double, pecten teeth very finely fringed; thorax very sparsely spicular, the abdomen glabrous *opisthopus*

Culex atratus Theob.

A small *Melanoconion* without special markings, this tropical mosquito was first taken in a light trap on Boca Chica Key, Fla., in 1942 (*195, 274*). The first larvae were collected on Elliott Key the next year in an abandoned fish pool, associated with *Culex bahamensis* (*331*). Larvae were taken in 1946 in a brackish roadside pool on Big Pine Key associated with *Culex iolambdis, Anopheles albimanus,* and *Uranotaenia lowii* (*253*). Others were found in 1947 in a man-made well in limestone on Ramrod Key, associated with *Culex mulrennani* (*18*). It was reported subsequently to be of widespread occurrence on the Keys. Two males were taken also in light traps on the mainland, one at Copeland in Collier County and one at Cortez in Manatee County (*252*). Light-trap records of the Florida State Board of Health have added Lee and Dade Counties to the above list (*53*). Nothing is known of its biting habits. The species is known from the West Indies and Brazil.

Adult.—Proboscis, thorax, wings, and tarsi all dark. Occiput with several rows of broad, grayish scales bordering the eyes to vertex. Wing length about 2.5 mm., the scales broadened on the forks of veins 2 and 4. Abdomen unbanded. Male dististyle slender and gradually tapered from base to tip. Basal division of the subapical lobe of basistyle with a single arm having a filament at tip and a bristle from near the base; an expanded leaflet present on the apical division of the subapical lobe; one to six broad curved filaments near the base of the basal division. Lobes of ninth tergite large, somewhat gourd-shaped or pear-shaped, with the neck drawn out to a blunt point.

Larva.—Lower head hair long, single; the upper, four- to six-branched, less than half as long as lower. Thorax finely spicular, the abdomen less so. Comb scales in a large patch, each rounded and completely fringed. Air tube about 8:1, with four or five pairs of multiple ventral tufts, the proximal pair a little longer than diameter of tube, and with two or three small dorso-lateral tufts; pecten teeth with about 12 coarse side spinules. Gills shorter than segment.

Culex bahamensis D. and K.

(Syn., *C. corniger* of Dyar (not Theob.))

This is one of the few species of *Culex* with tarsal white rings. It is a tropical species that has evidently become established in southern Florida. It was previously listed from Knight's Key, Elliott Key, and Key West (*193*). More recently it has been reported to be of widespread occurrence on the Keys (*252*), and has been taken also on the mainland in Dade and Broward Counties (*53*). Fisk (*110*) collected the larvae in several breeding places at Key West, including an underground cistern containing brackish water. Wirth (*331*) reported the collection of larvae on Elliott Key in 1943 from an abandoned fish pool associated

with *C. atratus,* and on Key Largo in 1944 in a brackish pothole or pool about 10 × 15 feet in size associated with *Aedes taeniorhynchus, Deinocerites cancer,* and *Culex elevator* (= *iolambdis*). This pool contained water of about half the salt concentration of sea water. Nothing has been published on the habits of the adults on the Keys. The species is known from Puerto Rico and Jamaica, the larvae having been taken in mangrove swamps and rock holes along the coast in the latter place.

ADULT.—Proboscis with a prominent white ring at middle. Occiput with pale narrow scales. Mesonotum dark, with paler scales laterally and around prescutellar space, sometimes with a pair of central submedian spots or short streaks. Wing about 3 mm., all dark. Femora, tibiae, and first tarsal segment pale on one side, dark elsewhere. Hind tarsi with narrow apical and basal white rings, the fore and mid tarsi with still narrower rings usually confined to the base of the segments.

LARVA.—Comb scales in a patch, each scale completely fringed. Air tube about 4:1, rather densely spiculate, with six or seven pairs of bushy ventral tufts, the first two inserted before end of pecten; pecten spines with two or three coarse side teeth on basal half, the distal spines more widely spaced than the others. Plate of anal segment with a pigmented dorsal area. Only one pair of gills, very short, bulbous.

CULEX ERRATICUS D. and K.

(Syn., *C. egberti* D. and K., *C. leprincei* D. and K., *C. pose* D. and K., etc. Also references to *C. abominator* (not D. and K.) in the Southeastern States, *C. inhibitator* (not D. and K.) in the United States, and *Melanoconion atratus* of Dyar (not *Culex atratus* Theob.))

This small *Melanoconion* has been known under numerous names, the principal ones in the United States listed above. The extensive synonymy of the species has been discussed by King and Bradley (*189*). The larvae are found in grassy permanent ponds and swampy places, especially those having a sparse or moderately dense growth of duckweed (*Lemna*). They are by far the commonest *Melanoconion* in most of the southeastern area. Deposition of the egg raft on the upper surface of the *Lemna* frond has been observed in Illinois (*78*) and was also observed frequently at Mound, La.

The larvae are taken frequently in association with those of *Anopheles quadrimaculatus.* Identified as *C. inhibitator,* they were reported to occur in enormous numbers in ricefields in Arkansas in association with species of *Psorophora* (*157*). In Illinois they were especially numerous in ponds with growths of cattail and waterprimrose. In Tennessee, they were taken in association with 10 other species, mainly *Anopheles quadrimaculatus, A. punctipennis,* and *Culex territans* (*290*).

The writers have taken *Melanoconion* females, probably all *erraticus,* in Florida and Louisiana out of doors at night, while these mosquitoes were biting, but always in small numbers compared with the abundance of larvae. Observations at Mound, La., indicated that the species had a preference for the blood of fowls, and attacked them on the roosts at night. According to Thibault (*303*), *Culex abominator* (probably *erraticus*) was the most abundant and annoying species in the woods in the vicinity of Scott, Ark., especially at dusk and early in the morning, but con-

tinued to bite throughout the day. Horsfall (*156, 157*), however, did not include the species among those of economic importance in southeastern Arkansas where it was developing in very large numbers in ricefields. Ross (*270*) found the species abundant in southern Illinois, and said that the adults attack with persistence and inflict painful bites. *Erraticus* adults are attracted to light traps and have been taken in large numbers in Florida.

This species has been found in all the Southeastern States and has been reported from Texas to North Dakota and Michigan, and eastward to Maryland. It is widely distributed also in the Caribbean region.

ADULT.—Proboscis, thorax, wings, and legs all dark. Occiput with a large dorsal triangular patch of lanceolate scales and one or two rows of broad greyish scales bordering the eyes to the vertex, with the usual lateral patches of broad appressed whitish scales. Mesonotal scaling often bronzy or golden, especially in the western part of its range. Wing 2.5 to 3.0 mm., with short, broadened scales, especially on the forked veins. Abdominal tergites with narrow, white basal bands or lateral spots. In the male the swelling of the dististyle is moderate and gradually tapered. Subapical lobe of basistyle with an expanded, wrinkled leaflet on the apical division; basal division divided into two subequal arms, each with a stout apical filament. Plate of mesosome with an apical and subapical tooth on the outer margin. Lobes of the ninth tergite large, ovate, diverging at an angle, and covered with slender bristles.

LARVA.—Lower head hair single, the upper much shorter, multiple. Body spicular-pilose, usually densely so. Comb scales long, pointed, fringed laterally on basal half, in a single irregular or partly double row. Air tube about 6:1, usually with five pairs of multiple ventral tufts inserted beyond pecten, the proximal pair about twice as long as the diameter of tube; two pairs of small subdorsal tufts; pecten spines fringed on one side to tip. Anal gills somewhat shorter than the segment.

CULEX IOLAMBDIS Dyar

(Syn., *C. elevator* of Wirth (not D. and K.))

This tropical *Melanoconion* was first reported in the United States by Wirth (*331*) based on a collection of larvae and pupae obtained in 1944 on Key Largo, Fla., and originally identified as *Culex elevator*. A collection was made on Big Pine Key in 1946 (*253*) and the next year collections were made on Ramrod Key and Key Vaca (*252*). These specimens were all identified as *elevator* but the identification was corrected to *C. iolambdis* by Pratt and Seabrook (*250*), who reported the species from Martin County and several localities in Palm Beach County on the mainland. Records of the Florida State Board of Health have added Dade, Collier, Lee, and Manatee Counties to the list, the last three being on the west coast.

The larvae on Key Largo were taken in a brackish-water pool, about 10 × 15 feet in size, associated with *C. bahamensis* and *Aedes taeniorhynchus*. The water in the pool contained salt in about half the concentration of sea water. The collection on Big Pine Key was in a brackish roadside pool, and those in Palm Beach and Martin Counties were in pools among the aerial roots of black mangrove, or in mixed stands of black and white mangrove. Similar breeding habits were reported for the species in Panama and Puerto Rico (*250*). The adults are attracted to light traps and were taken in Florida resting on tree trunks and decaying branches. There are no reports of their biting habits.

ADULT.—Proboscis, thorax, wings, and tarsi all dark. Occiput covered almost entirely with broad, appressed, dusky scales. Wing length about 2.5 mm., with short, broad scales particularly on the forks of vein 2. Abdomen entirely dark dorsally. Male dististyle moderately enlarged apically and tapered toward tip; apical lobe of basistyle lacking broadened leaflet; basal lobe divided into two arms, each with a long stout filament of about equal size. Plate of mesosome with a strong subapical tooth on the outer border and several minute teeth near tip. Lobes of ninth tergite ovate, moderately large.

LARVA.—Lower head hair single, the upper usually single, or if double, not split to base, about half as long as lower. Thorax and abdomen sparsely pilose. Comb scales in a large patch, each rounded and fringed. Air tube about 6:1, with four or five pairs of multiple tufts, the proximal tufts about twice as long as the diameter of the tube, inserted beyond pecten; spines of pecten fringed on one side to tip with about 15 fairly coarse spinules; tube with a dark pigmented band near middle. Anal gills somewhat shorter than segment.

CULEX MULRENNANI Basham

This species of *Melanoconion* is known only from the Florida Keys. It was described by Basham (*18*) from seven males collected in 1945 from limestone solution holes on Big Pine Key, Monroe County, Fla., and from larvae and reared adults collected in 1947 from potholes and a man-made well in limestone formation on Big Pine and Ramrod Keys. Among the paratype specimens are listed three larvae collected from Cudjoe Key in 1945. The larvae in the well on Ramrod Key were associated with *C. atratus* and an unidentified species of *Melanoconion*. Two of the holes on Big Pine Key were only 6 and 8 inches in diameter at the top and about 8 feet deep, with the water surface 6 feet below ground level. A few adults were collected from the sides of the solution holes. There was no record of biting. Three additional males were collected in light traps on Big Pine Key in 1953 (*53*).

ADULT.—A very small species with the proboscis, thorax, wings, and tarsi all dark. Occiput almost entirely covered with broad appressed dusky or opalescent scales, and a few narrow curved scales posteriorly. Wing length about 2.0 mm., with broad, ovate scales on the forked veins. Abdomen with minute basal lateral white spots, larger in the male. Apical half of male dististyle greatly enlarged and then tapered to the tip. Apical division of the subapical lobe of basistyle bears a moderately broadened, striated leaflet, three or four times as long as the greatest width; basal division divided into two arms, each with a stout filament of about equal size at tip. Lobes of the ninth tergite much enlarged, each with an outer thumblike or conical projection, bristly at tip.

LARVA.—Lower head hair single, the upper about half as long, usually triple, sometimes two- or four-branched. Thorax sparsely spiculate, abdomen apparently glabrous. Comb scales in a large patch, each rounded and fringed. Air tube about 6:1, with five or six long multiple ventral tufts beyond pecten, and two pairs of small subdorsal tufts; pecten teeth fringed on one side to tip with coarse spinules. Anal gills shorter than segment.

CULEX NIGRIPALPUS Theob.

(Syn., *C. similis* Theob., etc.)

A medium-size, dark *Culex* with the abdomen unbanded. The larvae are common in ditches, fresh-water marshes, and grassy pools in central and southern Florida, where the species appears to have largely replaced its near relative, *Culex salinarius*. They are also found commonly on the Keys (*252*). Elsewhere in the Southeast they are usually of scattered or rare occurrence.

Judging by the small number of biting records obtained by the writers in Florida in comparison with the abundance of the larvae, the species is much less inclined to attack persons than is *salinarius*. The adults are attracted to light traps and have been taken occasionally resting in houses. It is not considered of importance as a pest of man. Provost (*258*) has published some interesting comparative collection records for this and other species obtained in a series of night collections in 1954 at Leesburg, Fla. The total numbers of female *Culex* (*Culex*), most of which were said to be *nigripalpus,* taken during 48 nights in different types of collections, and the percentage of the total specimens caught by that method were as follows: Truck trap, 1,003 (12); light traps, 545 (9); goat-baited animal trap, 179 (9); calf-baited trap, 3,689 (35), and biting collections on man, 4 (0.3). The truck trap consisted of a screened cone mounted on top of a small truck that was driven around the area and was considered the standard in showing the relative proportions of the different species. It will be noted that the calf-baited trap was by far the most attractive of the several types.

Since our previous publication (*193*), *nigripalpus* has been recorded from Mississippi (*337, 245*), Tennessee (*228, 290*), and North Carolina (*66*). With the exception of Arkansas, this completes the list of the Southeastern States. It is known also from Texas, Mexico, Central America, and northern South America.

ADULT.—Proboscis, thorax, wings, and tarsi all dark, and distinctly darker in appearance than the related *C. salinarius*. Occiput with only lanceolate and upright forked scales. Pleura with very few scales, usually limited to less than a half dozen on any of the sclerites, or entirely bare. Wing about 3.5 mm., the scales long and narrow. Abdomen dark above except for small lateral white spots on part of the segments. Subapical lobe of dististyle with five appendages, consisting of a seta followed by a moderate-size leaflet, and three long rods, hooked at tip. Mesosomal plate divided into two arms with a median row of four to seven teeth, the dorsal arm straight, stout, arising near base of plate. Tenth sternite with the usual pointed bristles on the inner side, but with short blunt spines on the outer side; basal arm long and strongly curved.

LARVA.—Upper and lower head hairs both long, subequal, and usually three-branched. Thorax sparsely covered with fine spicules. Hair 1 (inner submedian) of mesothorax about equal in size to hair 2 and separated from it about the same distance as hair 2 from hair 8 (*88*). Comb scales in a patch, each rounded and fringed. Air tube slender, about 6:1 or 7:1, with four pairs of hair tufts, the middle two placed more laterally than the other two, the proximal tuft usually double or long and single, occasionally triple, the next two tufts usually triple; pecten short, the single spine with four to six coarse teeth on one side nearly to tip. Lateral hair of anal segment usually single. Gills somewhat longer than the segment.

CULEX OPISTHOPUS Komp

This small tropical *Melanoconion* is the only United States member of the subgenus with white rings on the hind tarsi. It was first recorded from Florida by Pratt *et al.* (*251*), who collected larvae and pupae from several holes of the land crab, *Cardisoma guanhumi* Latr., in a cypress and maple swamp about 3.5 miles inland from the coast near Fort Lauderdale, Fla. They were associated with *Deinocerites cancer*. These authors also state that the species was taken in Puerto Rico in sluggish streams and streamside pools among rank vegetation, where it was associated with *Culex erraticus, Uranotaenia lowii,* et cetera. Subsequently,

adults were taken in light-trap collections at Fort Lauderdale, Jupiter, Cape Sable, and Charlotte Harbor (*252*), and others in Dade, Collier, and Brevard Counties (*53*). It thus appears to be widespread in southern Florida although not yet recorded from the Keys. It has been reported also from Central America and Mexico.

ADULT.—Proboscis unbanded. Occiput with a rather large median area of broad dark scales anteriorly, narrower scales posteriorly, and fairly wide submedian stripes of narrow pale scales. Mesonotum dark except for small spots of paler scales on the front border and around the prescutellar space. Wing length about 2.5 mm., with distinctly broadened scales on the forks of veins 2 and 4, and the scales dense on the apical portions. Hind tarsi with very narrow apical and basal white rings on segments 2 to 4, and segment 5 all white or nearly so; fore and mid tarsi usually all dark. Abdomen all dark above with small lateral white spots on segments 6 and 7. Male abdominal tergites with distinct white basal bands that widen laterally. Male dististyle only slightly enlarged toward apex. Apical division of subapical lobe without a leaflet; the basal division divided into two equal short arms each with a long subequal filament. Mesosomal plate enlarged apically with a projection or tooth on the outside border. Lobes of ninth tergite elongate, fingerlike, with a wrinkled tip, well separated at base.

LARVA.—Lower head hair single, the upper usually five-branched, one-half to three-fourths as long as lower, both finely frayed. Abdomen glabrous, the thorax slightly spicular or sometimes apparently glabrous at least dorsally. Lower lateral hair on abdominal segment 1 (hair 7) double (*114*). Comb scales in a large patch, each rounded and fringed. Air tube about 8:1, with four pairs of small ventral hairs, the distal two usually double, the proximal two triple, little if any longer than diameter of tube; pecten tooth very finely fringed to tip. Gills shorter than anal segment.

CULEX PECCATOR D. and K.

(Syn., *C. incriminator* D. and K.)

The larvae of this small *Melanoconion* occur in grassy pools and swampy places, almost always associated with *Culex territans*. Nothing is known of its blood-feeding habits. The species is rare but has been taken in scattered localities in all the Southeastern States. It has been recorded from Texas to Michigan and eastward to Delaware. It is also reported from Puerto Rico (*114*).

ADULT.—Proboscis, thorax, wings, and tarsi all dark. Occiput with a fairly large dorsal area of broad dusky scales. Wing with short, broadened scales on the forked veins. Abdomen with lateral white spots and usually with small median basal spots on segments 2 to 4. In the male the apical half of the dististyle is greatly enlarged, quadrate, the upper margin hirsute. A very large wrinkled leaflet present on the subapical lobe of the basistyle; basal division with a single arm with a stout apical filament, and a second long, slender filament arising from a tubercle near its base. Plate of mesosome with an apical and subapical tooth or projection. Lobes of ninth tergite small, ovate with long setae.

LARVA.—Lower head hair single, the upper usually two- or three-branched, about half as long as lower. Body sparsely spicular. Comb scales in a patch, each rounded and fringed. Air tube about 6:1, usually with five pairs of multiple ventral tufts inserted beyond pecten, the proximal pair about twice as long as diameter of tube; spines of pecten fringed on one side to tip with moderately coarse teeth; tube with a pigmented band at the middle. Gills shorter than the anal segment.

The larval description by Dyar and Barret (*97*) was based on *Culex erraticus*. The description was corrected by King and Bradley (*189*).

CULEX PILOSUS (D. and K.)

(Syn., *Mochlostyrax floridanus* D. and K. etc.)

This very small *Melanoconion* breeds in shallow, grassy pools,

roadside ditches, hoof prints, and flooded areas. The eggs are able to withstand drying, a very unusual trait in the genus, and as a rule the breeding places are temporary. The collected larvae are easily recognized by their peculiar shimmying motions and by their habit of lying on their backs on the bottom of the container. Nothing is known of the habits of the adult. The species is common in Florida, including the Keys, and is often taken in large numbers in light traps.

C. pilosus was previously recorded from all the Southeastern States except Arkansas and Tennessee (*193*). In the United States it is known only from this area, but is widely distributed in the Caribbean area, as well as Mexico, and the northern part of South America.

ADULT.—Proboscis, thorax, wings, and tarsi all dark. Occiput with a moderately large dorsal area of broad dusky scales bordering the eyes and the usual triangular patch of lanceolate and upright forked scales behind. Wing length 2 to 2.5 mm., the forked veins with broadened scales. Apical part of dististyle of male enlarged, cap-shaped, and abruptly tapered. Subapical lobe with a rather narrow striated leaflet, the basal division of lobe with two subequal arms, each with a long stout filament, hooked at tip. Plate of mesosome with a small apical and subapical tooth on the outer margin, and two long, pointed projections from the inner margin. Ninth tergite with a widened plate, the lobes projecting backwards from its posterior corners as a pair of short, thumblike arms.

LARVA.—Upper and lower head hairs both comparatively short, single, the upper rarely double. At the base of each antenna, inserted near the preantennal tuft, is a unique, stalked, ovoid tracheal gill. Thorax slightly spicular. Comb with 8 to 12 scales in an irregular row, the single scale long, pointed, and with or without a minute lateral fringe basally. Air tube small, about 3:1, with about eight pairs of very long multiple tufts, the proximal two inserted before the end of the pecten, the others decreasing in length; two pairs of subdorsal tufts; pecten spines fringed to the tip. The two pairs of gills are of unequal length, the ventral pair nearly twice as long as the segment.

THE CULEX PIPIENS Complex

The so-called *Culex pipiens* complex consists of a number of closely related species, subspecies, and ecological variants occurring in various parts of the world whose exact relationship has not been fully established. A full discussion of the problem has been given by Mattingly *et al.* (*218, 219*). Four principal members of the complex are now recognized (*217*), three of which, *C. pipiens pipiens* L., *C. p. quinquefasciatus* Say (called *fatigans* in European and certain other countries), and *C. p. molestus* Forskål, occur in the United States. The fourth member, *C. p. pallens* Coq., is widely distributed in China and Japan. The recognition of *molestus* in the United States is comparatively recent and very little is known of its occurrence or distribution here. Morphologically, the arms of the mesosome are very similar to those of *pipiens* (*76*) and "its basic diagnostic characteristics" (*201*) are biological. It has the unusual ability to produce at least the first batch of eggs without a blood meal (autogeny) and to copulate in small spaces (stenogamy), whereas *pipiens*, as now restricted, requires a blood meal for egg production (anautogeny) and copulates on the wing, hence requiring greater space (eurogamy). Other biological, as well as some small morphological differences, have been described in the European area. For example, *pipiens* is said to feed principally, or exclusively, on avian hosts while *molestus*

will feed readily on man and other mammals, as well as birds. It is claimed that the *molestus* female does not develop an adipose body and therefore the species is unable to hibernate in the adult stage, as is usual with *pipiens*. *Molestus* occurs in underground sites such as subways, tunnels, and basements, where it is not subjected to freezing temperatures. In the United States, autogenous strains have been reported by Huff (*166*) and Richards (*264*) in Pennsylvania, Wray (*333*) in Illinois, Rozeboom (*276*) in Maryland, and Galindo (1943, cited by Rozeboom (*276*)) in California. So far, it has not been recognized in the Southern States although it should occur here if it actually is restricted in its ability to hibernate.

Considerable work has been done on the relationship of northern *pipiens* and southern *quinquefasciatus*, and it has been shown that they readily interbreed in the laboratory to produce healthy and fertile hybrids (*107, 302, 17, 277*). The known range of *pipiens* has now been extended well into the Southeastern States and as the range of *quinquefasciatus* extends into the Northern and Midwestern States, there is now a broad area where the two overlap. Male specimens with an intermediate type of mesosome have been collected in this area, indicating the occurrence of hybrids, which greatly complicates the matter of identification.

Culex pipiens pipiens L.

(The northern house mosquito)

This is one of the domestic mosquitoes, and is regarded generally as the most abundant night-biting, house mosquito in cities and towns of the Northern States. Its range also extends into the Southeastern States. It breeds in all sorts of artificial water containers, in street gutters and catch basins, open cesspools, and in ground pools if the water is polluted. It has always been regarded as a serious pest and is responsible for the continuing expenditure of large sums of money in urban antimosquito work.

As mentioned in the discussion of the *pipiens* complex, the European type form is believed to feed principally or entirely on avian hosts, and cannot ordinarily be induced to feed on man. Colonies of northern *C. p. pipiens* in the laboratory in Baltimore were never observed to bite persons either on the hands and arms in the cages or when loose in the room (*276*). Other laboratories have had difficulty in inducing them to feed on mammalian hosts (*199*). Richards (*264*), however, working in Philadelphia, saw no indication that the anautogenous strain shunned human blood; in fact, the contrary was true. In view of the many reports of the pestiferous nature of the northern house mosquito, it appears that the commoner populations differ from the typical European *pipiens* in this respect. Smith (*292*) reported that, with the exception of the salt marsh mosquitoes, *pipiens* was the most offensive and troublesome mosquito in New Jersey, and in many places the only troublesome species. He stated that it winters in the adult stage, the favorite places being barns, cellars, and ordinary outbuildings, and that blood meals were not necessary for this species. Howard, Dyar, and Knab (*163*) wrote that there is reason to suppose that these species (*pipiens* and *quinquefasciatus*) are

primarily persecutors of poultry. Reeves and Hammon (*261*) found that of 52 freshly engorged, wild-caught females of *pipiens* in the Yakima Valley, Wash., tested by the precipitin method, 76 percent had fed on birds, the rest on horses, cows, or dogs. It is possible, of course, that *molestus* is the species observed to be annoying to man even though it can propagate without the necessity of a blood meal. If so, however, it would appear to differ from European *molestus* in its ability to overwinter as fertilized females. Shute (*291*) has already suggested that the carrier of the virus of St. Louis encephalitis (reported as *Culex pipiens*) is not true *pipiens* if this form never, or very rarely, feeds on mammals. Richards (*264*) thought it probable that we do not have an exact duplicate of the European situation. Much more study needs to be given to the problem in the United States to clarify the relationships. At present there is little or no information as to the bionomics of the *pipiens* found in the Southeastern States. In the North it is not considered to be a migratory species ordinarily, but may cover considerable distance at times. Adults were taken in two light traps in Delaware Bay about 8 miles from the nearest shore (*209*), and in Illinois several stained adults of both sexes were recovered at a distance of 14 miles from the place where they were stained (*77*).

C. pipiens was considered to be the principal vector of St. Louis encephalitis during the outbreak of 1933 in St. Louis. It has been shown to be capable of transmitting this virus experimentally (*262*), and the viruses of both western equine and St. Louis encephalitis have been recovered once each from pools of specimens collected in the Yakima Valley, Wash. (*261, 138*). It is considered to be an efficient vector of human filaria and a moderately efficient host of dog heartworm, and it was shown to be capable of transmitting fowl pox experimentally (*200*).

Numerous additional records of *C. p. pipiens* in the Southeastern States were accumulated from mosquito collections made during World War II, and its known distribution in 1944 was given as all of Tennessee and North Carolina, approximately the northern halves of South Carolina, Georgia, and Alabama, and the extreme northern part of Mississippi (*317*). Its distribution has been discussed also by Barr (*16*).

ADULT.—Proboscis, wings, and tarsi all dark. Dorsal area of the occiput without broad scales. Scales on thorax lanceolate, pale brown or grayish in color, and with a distinctly coarser appearance than scales of *C. restuans* and *C. salinarius*. Wing about 4.0 mm., the scales long and slender. Abdominal tergites with broad white basal bands continuous with the lateral spots, their posterior borders more or less straight, not evenly rounded as in *C. p. quinquefasciatus*. Subapical lobe of the male dististyle with eight appendages consisting of a long seta, a moderately widened leaflet, three short rods or filaments with slightly curved or hooked tips, and three longer rods with hooked tips. Bristles of the tenth sternite all slender and pointed; the basal arm short and thumblike. Each plate of mesosome with two large arms, the ventral one ribbonlike, curved sharply outward toward the basistyle at about the outer third, and tapered to a point; the dorsal arm fairly broad, semicylindrical in appearance, with a truncate, slightly upturned tip, placed obliquely and typically extending to or toward the tip of the ventral arm.

The shape and direction of the dorsal arm are the principal means of distinguishing *C. p. pipiens* from *C. p. quinquefasciatus*. The DV/D ratio has been used as a measure of the position of the two arms (*302*), DV being the distance between the tips of the

dorsal and ventral arms on one side and D the distance between the tips of the dorsal arms. In a series of measurements of specimens maintained in colonies in Baltimore, the mean for specimens from a *pipiens* colony was 8.9/89.2 μ and the means from two *quinquefasciatus* colonies were 59.8/64.2 and 66.2/64.2 μ., giving ratios of about 0.1 versus 0.9 and 1.0, with no overlapping of the ratios, showing that the position of the arms was a certain means of distinguishing typical specimens. A series of hybrids gave intermediate ratios, overlapping the range of measurements for both species. A small number of wild-caught males from different localities disclosed the presence of a few with intermediate ratios in areas where the ranges of the two species overlap. Similar results with the same Baltimore colonies were obtained by subsequent workers (*17*).

LARVA.—Upper and lower head hairs large, multiple, and equal in size. Body glabrous. Lateral hairs of abdominal segments 3 to 5 nearly always double. Comb scales in a patch, each rounded and fringed. Air tube about 4:1, with four pairs of hair tufts, the proximal two multiple, about as long as diameter of the tube, the third pair double or triple and inserted laterally out of line with the others, the distal pair usually double. Pecten teeth with coarse spines on one side on basal half. Anal gills somewhat longer than segment.

CULEX PIPIENS QUINQUEFASCIATUS Say

(Syn., *C. fatigans* Wied., *C. pungens* Wied., etc.; the southern house mosquito, or house *Culex*)

The name *fatigans* is employed for this species by the European workers and is in use in most of the Old World countries. Stone (*298*) has discussed the reasons for retaining the name *quinquefasciatus* which is now considered merely a subspecies of *pipiens*. It is chiefly an urban domestic species and its habits are similar to those of the northern house mosquito. It breeds prolifically in street gutters, storm-water catch basins, cesspools, and open septic tanks, in water barrels, tin cans, and other artificial water containers and also in ground pools if the water is polluted. It is generally regarded as the most abundant nightbiting house mosquito in the cities and towns of the Southern States.

Very little information has been published on its biting habits and host preferences in the United States. In New Orleans, La., the larvae were observed in enormous numbers in the ill-smelling street gutters, before storm sewers were widely installed. The females were a serious pest, and bed nets were required for protection against them in unscreened, or poorly screened, houses. They were said to be a major pest at Columbus, Ga. (*112*), and in southern Mississippi were reported to bite freely during twilight and dark, and to enter buildings regularly (*225*). At Orlando, in central Florida, however, observation by the present writers indicated that, although numerous, the species was of little, if any, importance as a pest of persons. Biting collections made after dark failed on many occasions to produce a single *quinquefasciatus* although they were shown to be numerous by light-trap and rotating-trap collections, as well as by the numerous egg rafts obtained in tubs of polluted water placed in the laboratory yard for egg collecting. Efforts to obtain engorged females for an examination of the blood were of no avail as the daytime resting

places were not located. Mosquito-control workers report that the species is of little importance in other parts of southern Florida. Kitzmiller (*199*) observed that a laboratory colony, originally obtained from Texas, fed readily on pigeons and chickens, but reluctantly on persons.

Blood meals from 266 *quinquefasciatus* in southern California, identified by the precipitin method, showed 88 percent had fed on birds and the rest on horse, cow, or dog (*139*). In Alabama, over 99 percent of the engorged females, whose blood meals could be determined by serological or microscopic methods, were found to have fed on avian blood (*101*). These were collected at the Alabama Agricultural Experiment Station, presumably around poultry houses. In other parts of the world there are records of a high percentage of *fatigans* containing human blood: 87 percent of 352 females caught in dwellings in Guam, 77 percent and 50 percent of specimens caught in two houses in the Belgian Congo, all of 96 specimens collected in dwellings in Indochina, and 94 percent of females caught in stables there (cited by Horsfall, (*160*)). In Puerto Rico hundreds of females, mostly engorged, could be collected at any time in the poorer, crowded dwellings (*241*). In the extreme southern part of the United States breeding may continue throughout the winter and has been observed as far north as Columbus, Ga. (*112*). In the more northern part of their range they hibernate as adult females.

Experimental transmission of the virus of St. Louis encephalitis was obtained with *C. p. quinquefasciatus* from California, but not with the same species from Texas (*135*). In laboratory tests with the viruses of both western and eastern equine encephalitis, its vector potential was rated as "poor" (*72*). The virus of WEE was recovered from specimens collected in Texas (*172*). This species also is a host of human filaria.

This is one of the commonest mosquitoes in the Southeastern States. Outside of this area it has been reported as far north and west as the District of Columbia, Missouri, Kansas, Utah, New Mexico, and California. It is found in the Tropics and subtropics throughout the world.

ADULT.—Proboscis, thorax, wings, and tarsi all dark. Mesonotum with a vestiture of grayish, lanceolate scales having a coarse appearance in comparison with *C. restuans* and *C. salinarius*, but similar to *pipiens*. Wing length about 4 mm., the scales long and slender. Abdominal segments with prominent white bands, usually with a smoothly rounded posterior border on segments 3 to 5, narrowly separated from the lateral spots. Typical specimens can usually be distinguished by this character from the other dark-legged species of subgenus *Culex*. The male genitalia are very similar to *pipiens* except for differences in the plates of the mesosome as previously discussed under the *pipiens* complex and the description of *C. p. pipiens*. In typical specimens the ventral arm is narrower and the apical portion distinctly longer and more tapered; the dorsal arm more slender, bluntly pointed, and directed almost straight backwards, instead of obliquely, about parallel to the inner margin of the ventral arm. The mean DV/D ratio was 0.9 and 1.0 in two series of measurements. The basal arm of the tenth sternite is short and stubby, usually shorter than in *pipiens*.

LARVA.—The larvae of the two species appear almost identical, and no certain characters for separating them have been found.

CULEX RESTUANS Theob.

(Syn., *C. territans* in some early literature (not of Walker); the white-dotted *Culex*))

This medium-size species has one or two pairs of small white dots on the thorax and broad white bands on the abdomen. The larvae occur in permanent or semipermanent ground pools, ditches, and rainbarrels, preferring somewhat foul water, especially that containing decaying grass and leaves. The species becomes locally abundant in the South, much more so during the fall, winter, and spring than in the summer. In northern Alabama the larvae were found associated with *Aedes thibaulti* in hollow stumps and basal cavities of gum trees (*287*). In Tennessee it was taken in association with 18 species, most frequently with *Culex apicalis* (= *territans* Wlk.), *Anopheles punctipennis, Culex pipiens quinquefasciatus, Aedes vexans,* and *Culex salinarius* (*290*).

C. restuans has sometimes been regarded as a troublesome biter, and the writers have records of their biting persons in Louisiana. Michener (*225*) in southern Mississippi stated that it was rarely seen biting even when abundant. Thibault (*303*) in Arkansas wrote that it did not bite human beings very much, though it entered houses. It seemed to prefer poultry and livestock, and also juices of plants. Headlee (*142*) said that the adults get into houses in New Jersey and occasion a considerable amount of annoyance.

This species has been collected in all the Southeastern States. It is widely distributed throughout the eastern United States and southern Canada and as far west as Utah and Wyoming, and has been recorded in Mexico.

ADULT.—Proboscis, wings, and tarsi all dark. Mesonotum nearly always with one or two pairs of small white dots near the middle (fig. 19, *K*) and grayish scales around the margins, the vestiture otherwise of fine, brownish, hairlike scales giving the mesonotum a smooth appearance in comparison with the rougher appearance of *C. p. pipiens* and *p. quinquefasciatus*. Wing length about 4 mm. or slightly more, the scales long and slender. Abdomen with wide white bands continuous with the lateral spots. In the male the appendages of the subapical lobe consist of a seta, a short rod with a hooked tip, a small leaflet, and three slender rods with hooked tips. Plates of mesosome each with a fairly long, slightly curved, ventral arm and a short, stout, dorsal arm. Arms of the tenth sternite long and moderately curved, the bristles of the apical tuft all slender and pointed.

LARVA.—Upper and lower head hairs large, multiple, and about equal in size. Body glabrous. Comb scales in a patch, each rounded and fringed. Air tube about 4.5:1 with four pairs of hairs irregularly placed on the sides of the tube, the first three long, single, the distal pair shorter and double or triple; pecten spines with a few coarse teeth on basal half. Gills about twice as long as the segment.

CULEX SALINARIUS Coq.

A medium-size, light-brown mosquito, with or without narrow basal bands of yellowish scales on the abdominal tergites. The larvae are found in grassy pools, ditches, and marshy places, and sometimes also in water barrels and in the bilge water of boats. It was named under the supposition apparently that it was a salt-water breeder, and in the New Jersey publications it is listed as one of the salt-marsh species. Dyar and Knab (*98*), however, stated that it did not breed in salt water and subsequent observations have shown that it occurs principally in fairly clean, fresh-

water sites. No information is available as to its salt tolerance but it is known to occur at least in brackish water in salt marshes. Smith (*292*) wrote that they occur everywhere on the marsh in salt as well as fresh water, but as a rule more abundantly along the edges of the high land. In Tennessee, where the species was reported to be fairly abundant, the larvae were found associated with a total of 14 other species, most frequently with *Culex restuans, C. apicalis* (= *territans*), *C. pipiens quinquefasciatus,* and *Anopheles punctipennis* (*290*).

The females bite freely out of doors at night and are occasionally found in buildings. They are seldom of much importance as a pest in the South but are regarded as important at times in New Jersey (*142*). Smith (*292*) stated that they bit greedily in the early evening. In a series of collections made in Delaware (*167*), *C. salinarius* constituted more than half of the total mosquitoes taken in several types of collections, and many were collected while biting during the first 3-hour period after dark. Nearly 10 times as many were taken in a light trap from which CO_2 was emitted (from dry ice) than in a nearby trap using only the light. The number in the latter trap was nearly equaled by that in a third trap that was kept dark and CO_2 alone was used as the attractant. The adults may disperse quite widely from the breeding places. They were taken in two light traps in Delaware Bay about 8 miles from the nearest shore (*209*). Three of 34 specimens were males.

C. salinarius occurs in all the Southeastern States. It is common along the Gulf and Atlantic Coasts and less abundant inland. It is not abundant in peninsular Florida or the Keys, although it became more numerous at Orlando during the winter. The species is widespread in the Eastern and Midwestern States, and has been reported from southern Canada and Mexico.

ADULT.—Proboscis, thorax, wings, and tarsi all dark, with a generally brownish or golden-brown color. Pleura with three or four groups of white scales. Wing length about 4 mm., the scales long and slender. Abdomen with narrow, yellowish, transverse bands, or with at least a few yellowish or dingy white scales at the base of some segments; the segments sometimes also with scattered yellowing scales apically and the seventh segment frequently entirely yellowish scaled. In the male the appendages of the subapical lobe consist of two setae, one with a hooked tip, followed by a fairly large leaflet and three slender rods with hooked tips. Basal arms of the tenth sternite long and curved, the spines or bristles of the apical tuft all slender and pointed. Plates of the mesosome each with two arms and a median row or group of strong pointed teeth, the ventral arm long, stout, bluntly pointed and with a blunt tooth on the inner margin, the dorsal arm short, bent backwards in the middle at a right angle, thumblike, sharply pointed.

LARVA.—Upper and lower head hairs large, multiple, and equal in size. Body glabrous. Hair 1 (inner submedian) of mesothorax much larger than hair 2. and separated from it by a greater distance than hair 2 from 3 (*88*). Comb scales in a patch, each rounded and fringed. Air tube 6:1 to 8:1, with four pairs of tufts, the first two usually three- or four-branched, the last two usually double, the third pair set laterally on the tube, out of line with the others; pecten teeth with a few coarse teeth on basal half. Gills about as long as the segment.

CULEX TARSALIS Coq.

This mosquito is recognized by the wide white rings on the proboscis, apical and basal rings on the tarsal segments, and

white lines on the legs. It is typically a western mosquito that reaches its greatest abundance in irrigated areas of the Great Plains and western regions. It has invaded the Southeast in comparatively small numbers. The larvae have been reported from a great variety of more or less permanent breeding places including ditches, seepage areas, grassy pools and ponds, unshaded swampy places, flood waters, and artificial containers. In northern Louisiana the larvae were collected once by the writers in a clay borrow pit with *Anopheles punctipennis*. In the Tennessee Valley it favored small-pool areas such as grassy ditches, seeps, hoof prints, and polluted pools rather than large bodies of a more permanent nature. It was not found in leafy pools or in rocky stream beds. It was usually associated with *Anopheles punctipennis* and frequently with *Culex restuans, salinarius,* and *territans*. It occurred chiefly from late August to late November, with a peak in September (*294*).

In the Western States the females of *C. tarsalis* are said to be troublesome biters, but show a preference for avian hosts. It is of great economic importance because of its relation to the transmission of western equine encephalitis, of which it probably is the chief vector among domestic fowls and wild birds. It is capable of laboratory transmission of the disease, and the virus has been recovered many times from wild-caught specimens.

C. tarsalis was previously listed from Arkansas, Louisiana, Tennessee, and Florida (*193*). Collections during the war years showed it to be more widely distributed in the Southeast than previously suspected and added Georgia and Alabama (*228*), Mississippi (*228, 225*), and South Carolina (*320*). This leaves North Carolina the only State in this area from which it has not been reported. In Florida it has been taken in light traps in the northwestern counties and along the Gulf Coast as far south as Sarasota County (*52*). It occurs in the Western and Midwestern States to Indiana, and has been found in southwestern Canada and Mexico.

ADULT.—Proboscis with a wide white ring in the middle. Occiput with a large median area of whitish lanceolate scales. Scales of mesonotum mostly dark brown, usually with paler ones in short submedian lines posteriorly and around the prescutellar space. Lobes of scutellum with dark scales. Wing length about 4 mm., the costa and subcosta with scattered white scales and usually a patch of white at base, the other veins all dark, the scales long and slender. Femora and tibia pale-scaled posteriorly, with a complete or broken line of scales on the dark outer surface. extending onto the first tarsal segments; hind tarsal segments with comparatively wide basal and apical rings; the fore and mid tarsi with similar but narrower rings on the first three or four segments. Abdomen with wide white basal bands continuous with the lateral spots, the eighth segment sometimes entirely white-scaled.

LARVA.—Upper and lower head hairs large, multiple. Body glabrous. Comb scales in a patch, each rounded and fringed. Air tube about 5:1 with five pairs of multiple tufts, the proximal ones slightly longer than the diameter of the tube, all set in a straight line starting near or slightly before the end of the pecten; pecten teeth with coarse side teeth on basal half or two-thirds. Gills slightly longer than anal segment.

CULEX TERRITANS Wlk.

(Syn., *C. apicalis* of recent authors (not of Adams), *C. saxatilis* Gros., etc.)

This rather small, dark mosquito is distinguished by the presence of white apical bands or lateral spots on the abdominal segments, instead of basal as in other *Culex*. It is the only southeastern species of subgenus *Neoculex*. It was previously listed as *Culex apicalis* Adams but Bohart (*31*) has shown that *territans* is distinct from *apicalis*, and that the latter occurs only in the Southwest.

The larvae of *C. territans* are found in grassy pools, ditches, and open swampy places containing aquatic vegetation. They are often associated with *Anopheles*. In Illinois, it was said to be a cold-water form and practically to disappear during the hot summer (*270*). In Tennessee, it was found associated with a total of 17 other species, most frequently with *Anopheles punctipennis* and *Culex restuans* (*290*). The species is fairly common but the adults are seldom seen and evidently do not attack man. They have been observed by several persons feeding on frogs, and are believed to live on cold-blooded animals. Matheson (*213*) said that he could not induce the females to feed on him. They are able to fly considerable distances as specimens were caught in light traps in Delaware Bay, from which the nearest shore was about 8 miles. Two of seven specimens were males (*209*). *C. territans* has been recorded from all the Southeastern States (*193*), and is found throughout the United States, as well as in British Columbia and in Europe.

ADULT.—Proboscis, wings, and tarsi all dark. Occiput with pale, narrow curved scales dorsally. Mesonotal scales fine and brown or light brown in color except for pale scales around the front margin and the prescutellar space; lobes of scutellum also with pale scales. Wing length about 3 to 3.5 mm. Abdominal segments usually with narrow white bands on the posterior margins, sometimes all dark except for lateral apical spots. In the male the subapical lobe of the basistyle is undivided and without a leaflet, the appendages consisting of three small hooked rods, serrated distally, a still smaller rod, nonserrated, a strong bristle, and two long, strong rods with pointed, recurved tips. Tenth sternite with a row of short blunt teeth apically as in subgenus *Melanoconion* but the arm obliquely bent instead of at right angles. Paired plates of the phallosome with a connecting bridge near the middle (H-shaped), the part of the plate beyond this bridge fingerlike and studded at apex. Lobes of the ninth tergite small, discrete, and ovate.

Michener (*224*) has called attention to seasonal changes found in this species in the Southeastern States. The summer form tends to be smaller and the abdominal bands usually have only one or two rows of scales, sometimes represented only by lateral spots. The winter form tends to be larger and the abdominal bands have three, sometimes four, rows of scales, or rarely a partial fifth. The winter larvae are larger and darker. In Florida the summer form appears to occur throughout the year, while the winter form of the other Southeastern States is the one found throughout the year in the Northern States.

LARVA.—Upper and lower head hairs are usually both single, rarely double, the upper shorter than the lower. Body spicular-pilose. Comb scales in a patch, each rounded and fringed. Air tube about 6:1, slightly expanded at tip with four or five pairs of multiple tufts beyond the pecten, the proximal pair slightly longer than the diameter of tube, the distal pair

small, slightly out of line with the others; pecten spines with two or three coarse lateral teeth. Gills about equal to the anal segment in length.

Genus CULISETA Felt

(Syn., *Theobaldia* Neveu-Lemaire)

The eggs of *Culiseta* are laid in rafts, similar to those of *Culex*, and breeding is in more or less permanent water collections. The female palpi are short, the male palpi somewhat longer than the proboscis, the male antennae bushy, the scutellum trilobed, and the postnotum bare. The wing has a tuft of hairs on the underside at the base of the subcostal vein, the second marginal cell is as long as or longer that its stem, spiracular bristles are present, post-spiraculars absent. The tip of the abdomen is bluntly rounded, segment 8 visible, the cerci retracted. The dististyle of the male is slender, unmodified; the basistyle has a basal lobe bearing numerous bristles but is without a subapical lobe in our local species, and claspettes are absent. The larva has the general characteristics of genus *Culex* but differs chiefly in having a hair tuft at the base of the air tube and a paired ventro-lateral row of single hairs beyond the pecten (subgenus *Culiseta*), or a single mid-ventral row of small tufts beginning before the end of the pecten (subgenus *Climacura*). Only two species of this genus are found in the Southeast.

KEY TO SPECIES

ADULTS

1. Wing costa and vein 1, femur, and tibia sprinkled with white; the two cross-veins in center of wing separated by less than their length; wings unusually broad and lightly scaled, scales long and slender. A large species ..... subgenus *Culiseta, inornata*
   Wings and legs not sprinkled with white; the two cross-veins well separated; wing scales dense, broadened. Medium size .... subgenus *Climacura, melanura*

LARVAE (FOURTH INSTAR)

1. Both upper and lower head hairs multiple, long; air tube with a paired row of long setae beyond pecten (fig. 14, *C*) ..... *inornata*
   Lower head hair single, long, the upper much shorter, multiple; air tube with a median ventral row of small multiple hair tufts beginning before end of pecten ..... *melanura*

CULISETA INORNATA (Will.)

This rather large mosquito breeds in open grassy pools, ditches, marshes, and occasionally in artificial water receptacles. In the North it occurs throughout the summer but in the extreme South larvae and adults are encountered usually only during the cooler months, and are often associated with *C. restuans*. In New Orleans the larvae were sometimes found in abundance during the winter, but they disappeared completely from March to November, and the manner of passing the summer is unknown. It is possible that the eggs can withstand drying and go through a period of aestivation. This is suggested by the fact that larvae have been produced from dry material collected in the bottom of tree holes in Texas (*325*). It is perhaps more likely that the adults

aestivate as they apparently are unusually long-lived. Owen (*242*) recorded an average length of life of 95.8 days, with a maximum of 145 days, for females reared in a laboratory colony in Wyoming maintained in a basement room at a temperature of 60° to 70° F. A complete generation in this colony required about 30 days and blood was required for egg production, human blood being used in this case. In Tennessee this species was collected in all months of the year except June and July. The larvae were taken in association with 11 other species, most frequently with *Culex restuans, C. apicalis* (= *C. territans*), and *Anopheles punctipennis* (*290*).

The species is of little importance as a pest in the South. The writers have not observed it feeding on man, although it is said to do so at times. In Arkansas it was annoying before dawn in duck blinds in the rice-growing areas (*160*). Thibault (*303*), also from observation in Arkansas, wrote that it preferred horses and cattle to man and was very annoying to horses. It bit day or night, but mostly in the evening and night. It has been noted as biting man in several northern localities. Precipitin tests on freshly engorged females collected in the Yakima Valley, Washington, showed that the great majority (74 out of 86) had fed on horse or cow, whereas only one of the specimens gave a positive reaction for human blood. The others had fed on sheep or dog, or gave no reaction.

C. inornata has been recorded from all the Southeastern States and occurs throughout the United States. Its range extends into northern Mexico and southern Canada.

ADULT.—This is a large species, with a wing length of 5 to 6 mm. Proboscis and palpi sprinkled with white scales. Occiput with a large triangular area of narrow yellowish scales. Mesonotum speckled with pale scales. Wing unusually broad and lightly scaled; costa, subcosta, and vein 1 sprinkled with white; anterior and posterior cross-veins unusually close together, being separated by less than the length of one; a thick row of hairs or bristles on the underside of the wing at the base of the subcosta. Femora and tibiae, and usually the first tarsal segments, bear dark and white scales intermixed; tarsi not ringed. The abdominal segments with diffuse pale scaling basally and laterally, the eighth segment being entirely pale-scaled.

LARVA.—Antennal, preantennal, and upper and lower head hairs of larva all large and multiple; antennal hair set about the middle of the shaft, which is not notched. Body glabrous. Comb scales in a patch, each rounded and evenly fringed. Air tube about 3:1, with a pair of large multiple hair tufts near base and a paired row of 15 or more single hairs beyond the pecten; pecten spines long, slender, with a few coarse side teeth at base. Gills about as long as segment.

CULISETA MELANURA (Coq.)

Culiseta melanura is a medium-size mosquito, resembling a species of *Culex* much more than typical *Culiseta*. It can be recognized by its unusually long proboscis and dense wing scales. The larvae are found in small permanent collections of water, with or without vegetation. In Alabama they were found in water around the bases of trees and stumps, seeming to prefer places chosen by *Aedes thibaulti* (*287*); in Arkansas they occurred in abundance in October and November in open pools in muck lands (*157*); and in southern Mississippi they were collected in small grassy ponds of dark, acid water in a wooded swamp, in water

beneath hollow stumps and under the roots of trees, and once in a shaded barrel with *A. triseriatus* (*225*). In New Jersey, they were found in holes of spring water in sphagnum bogs (*292*). The larvae are said to overwinter under the ice in the North (*95, 213*). The adults are rare and of sylvan habits. They are attracted to light traps but apparently nothing is known of their feeding habits. In the laboratory, females, reared from larvae collected in Louisiana, fed, after being starved, on chicks and rabbits. They fed readily on soaked raisins. One female from a light-trap collection contained avian blood, as determined by the precipitin test (*73*). In Connecticut, reared adults in a cage would not feed on a human arm or on chicken (*315*). This author obtained a *Culex*-like egg raft from a wild-caught female, which is of interest because Dyar (*94*) stated that the eggs were laid singly on the water surface, an exceptional habit, if true, in this genus.

This species is now believed to be the vector of primary importance in transmitting the virus of eastern equine encephalitis from bird to bird.

C. melanura is known to occur in all the Southeastern States, Tennessee having been added to the previous State records (*193*) to complete the list (*260, 290, 228*). Its range covers most of the Eastern States and extends to the Rocky Mountains.

ADULT.—Proboscis, thorax, wings, tarsi, and dorsum of abdomen entirely dark-scaled. Proboscis unusually long. Occiput with pale narrow scales dorsally, no broad ones around eye margin at vertex. Wing length about 3.5 mm., the lateral scales dense, short, and broadened; anterior and posterior cross-veins separated by more than their own length. Abdomen all dark above, with small basal white spots, laterally. Tip of abdomen bluntly rounded, the eighth segment exserted.

LARVA.—Antennal tuft large, multiple, set in a constriction at about the apical fourth of shaft as in *Culex*. Lower head hair long, single, the upper with three or four branches, about half as long as lower. Body glabrous. Comb, a single even row of long, barlike scales, each rounded and finely fringed, the lateral margin scalloped. Air tube about 6:1, with a pair of small, double or triple hairs near base, and a long single row of about 15 short, multiple hairs on the mid-ventral line of tube beginning before the end of the pecten; pecten spines with two or three small side teeth near base. Gills about as long as the segment.

Genus DEINOCERITES Theobald

The species of this genus breed in holes of land crabs in coastal areas. The adults have a close general resemblence to *Culex*, but differ in a number of respects. The palpi are short in both sexes and the male antennae are unusually long being much longer than the proboscis, with the first flagellar segment as long as several of the succeeding segments. The male dististyle is pilose, somewhat enlarged toward the tip, the basistyle has a subapical and a basal lobe, neither of which is divided, and the basal lobe has two short, stout, hornlike spines. The tenth sternite has a transverse row of stout, blunt spines, the plates of the mesosome each with two stout blunt arms, and the ninth tergite with very long lobes, nearly as long as the basistyle. The larvae differ from other mosquitoes in having a triangular pouch on each side of the head, and the air tube has only two pairs of ventro-lateral hairs. Only one species has been found in the Southeastern States, and this one is limited to southern Florida.

DEINOCERITES CANCER Theob.

(Crab-hole mosquito)

The crab-hole mosquito breeds in holes made by land crabs (*Cardisoma guanhumi* Latr.) in the marl soil of the coastal salt marshes or in fresh-water, swampy places a short distance inland in southeastern Florida. They are most prevalent in brackish or salt-water habitats. The larvae have been found in association with quite a number of other species, both fresh-water and salt-marsh breeders, when the surface water left by rain or high tides had drained away. Near Fort Lauderdale they were associated with *C. opisthopus* in a cypress and maple swamp 3.5 miles inland (*251*). The adults may be found resting on the sides of the crab holes and are seldom seen otherwise. They are known to attack man occasionally at night but are not regarded of any economic importance, although they were on one occasion reported to be annoying enough to cause complaints of local residents in the eastern section of Hollywood, Fla. The complaints came from residential areas adjacent to undeveloped property containing a large number of crab holes. Annoyance was intense for a few days and then continued in a diminishing degree for more than a month (*25*).

In the United States *Deinocerites cancer* is limited to Florida, where it has been recorded as far north as Volusia County (*193*). It has been reported also from Flagler, St. Johns, Lake, Hernando, and Sarasota Counties, based on identifications of a single female in each county (*53*). It is fairly common on the Atlantic Coast from Palm Beach County south, including the Keys. The species occurs in the Carribean region and Mexico.

ADULT.—Proboscis, thorax, wings, tarsi, and dorsum of abdomen all black-scaled. Occiput with a dorsal triangular patch of brownish lanceolate scales. Mesonotum with fine hairlike scales. Sternopleuron densely shingled with broad, dark or dingy scales, abdomen without lateral white spots, the posterior segments compressed laterally making the height equal to the width, the cerci exserted. Male characters as described under the genus.

LARVA.—Triangular pouch on each side of larval head prominent, nearly as long as the head (fig. 16, *B*). Antennal and preantennal hairs multiple, the former not set in a notch. Lower head hair long, single, the upper multiple, about half as long. Comb, a large patch of scales, each rounded and evenly fringed around apex. Air tube about 4:1, with two pairs of ventrolateral hairs, one triple or double near middle of tube beyond pecten, the other small, usually single near tip of tube; a dorsolateral hair also present near tip; pecten spines long, pointed, with a long basal tooth. Anal segment with small sclerotized plates dorsally and ventrally. Only two anal gills, very short, bulbous.

Genus MANSONIA Blanchard

(Syn., *Taeniorhynchus* L.—Arr., *Coquillettidia* Dyar, etc.)

The species of *Mansonia* lay their eggs in rafts on marshes or shallow lakes having certain kinds of aquatic vegetation. Upon hatching, the young larvae descend below the surface of the water and attach themselves to aquatic plants by inserting the modified tip of the air tube into the stems and roots, through which they obtain air. The pupae also have breathing tubes specially modified for penetrating the soft tissues of plants, to which they remain attached until ready to transform to the adult stage,

when they rise to the surface. The winter is passed in the larval stage.

Because of their peculiar habits, *Mansonia* larvae are difficult to locate and special collecting methods must be employed. The plants to which *M. perturbans* attach themselves are usually rooted in the soft muck or vegetable debris on the bottom of the ponds. When these plants are uprooted many of the larvae detach themselves and will be missed if only the roots are searched. Because of this, the plants in a small area should be pulled up and swished around in the water to induce all larvae present to become detached. The bottom material is then scooped up with a large strainer and examined in small quantities in shallow pans in clear water (*210*). As the larvae usually remain on the bottom of the pan, a careful search must be made. The larvae are white or pale green in color, and their continuous movements aid in locating them among the trash. The search is tedious and time-consuming, but the work can be reduced somewhat by washing the material through two or three properly graded screens to eliminate much of the silt and coarse debris.

Another method, described by Bidlingmayer (*27, 28*), involves the use of an open-end metal cylinder 13.9 inches in diameter (1 square-foot area) and 30 inches high. This is used to enclose several host plants, with one end sunk into the bottom of the pond. The plants are uprooted, rinsed about in the water, and then discarded. All broken bits of roots and stems are also removed. An inverted metal funnel, the larger end of which fits snugly into the cylinder, is pushed down into the cylinder until the small end is one to two inches below the water surface. This insert is 12 inches high and the small end has an opening 1¾ inches in diameter. Soldered around the middle of the cone is a small cylinder 12½ inches high and 9 inches in diameter. Deprived of their source of air under water, the larvae eventually come to the surface and, after emerging from the end of the funnel, they can be removed from the small cylinder with a suction pipette. In the second article, the author (*28*) described another type of insert consisting of a cylinder in which the bottom was made up of about 12 small pyramids, each with a base 3½ inches square and a height of 2¾ inches, with a small opening in the tip of each. This type could be used in as little as 4 inches of water, whereas the cone type required about 14 inches, and tended to collect more sediment. The traps were usually left in the breeding places for 24 hours before the larvae were collected, but a shorter time suffices when the water is warm, or when the trap is set over floating plants. In another method (*259*), the same size of cylinder was used but magnesium sulphate was employed to increase the specific gravity of the water, and cause the larvae to come to the surface. After the plants were removed, the water was lowered in the cylinder to a depth of about 5 inches, and 1 pound of magnesium sulphate was dissolved and mixed in the water. The rest of the water and loose, bottom debris was then dipped out and placed in shallow pans, from which the larvae were removed as they surfaced.

The collection of the larvae of *M. titillans* and *M. indubitans*, which are mostly found on the roots of a floating plant, water-

lettuce, is much simpler. These larvae are readily taken by lifting the host plant quickly into a pan of water for examination, or the plants may be lifted from the water by bringing the pan or a cloth net up under them. Some larvae usually remain attached to the roots while others are found moving about in the dish. Specimens of *perturbans* may also be found on the same plants. The Bidlingmayer trap also may be used to collect larvae from floating plants and, since *titillans* and *indubitans* tend to come to the surface much faster than *perturbans*, the collections may be made from the traps after 2 or 3 hours.

The pupae of all three species also attach to plants (pl. 9, *A*). Dorer *et al.* (*90*) in Virginia, found that the pupae of *M. perturbans* did not release themselves when the host plants (arrowhead, in this case) were shaken. They were easily collected by pulling up a clump of plants, sloshing the roots about in the water to remove the soil and debris, and then swishing the plants violently in the air to leave the hairlike roots clean and dry. The attached pupae were then easily seen among the roots.

The genus *Mansonia* is of world-wide distribution and contains a large number of species that occur chiefly in tropical and subtropical areas. Only three species are found in the United States. The adults have the proboscis and tarsi ringed with white, and the wing scales are broad and mixed brown and white. The male palpi are long, the antennae bushy; spiracular bristles are lacking, postspiraculars present in most, but not in all, species. The tip of the female abdomen is blunt and somewhat compressed laterally, the eighth segment may be completely retracted and only the enlarged cerci visible. Some species have a row or group of spines at the tips of the seventh and eighth tergites. In the male, a basal lobe is present on the basistyle; a subapical lobe and claspettes are lacking. The larvae have a unique modification of the air tube which permits penetration of the roots or underwater stems of aquatic plants, the apical third being tapered to a point, with several saw-teeth on one side. The air tube lacks the usual pecten. The larval antenna is very long, nearly twice the length of the head, with a large tuft at the basal third and a pair of bristles arising beyond the middle of the shaft.

Two subgenera are represented by the three Southeastern species, *M. titillans* and *M. indubitans* being placed in subgenus *Mansonia*, and *M. perturbans* in *Coquillettidia*. Postspiracular bristles are present in the former but absent in the latter. *M. perturbans* also lacks spines at the tips of the seventh and eighth tergites in the female.

KEY TO SPECIES

ADULTS

1. First segment of hind tarsi with a wide pale ring at middle, and hind tibia with a preapical pale ring; proboscis broadly ringed; postspiracular hairs absent. Widely distributed in the United States and Canada ..... Subgenus *Coquillettidia*, *perturbans*
   Tibia and first hind tarsal segment unbanded or bands indistinct; postspiracular hairs present. Florida and the Tropics ..... Subgenus *Mansonia* 2
2. Tergite 7 of abdomen with a long row of pointed spines; tergite 8 with a close-set posterior row of about 8 stout, bluntly-

rounded spines, preceded by two laterally placed groups of 10 to 12 spines; palpi not more than one-third as long as proboscis ..... *titillans*

Tergite 7 without a posterior row of spines; tergite 8 with two long rows of stout pointed spines, not closely set; palpi nearly half as long as proboscis ..... *indubitans*

LARVAE (FOURTH INSTAR)

1. Antenna with a pair of very short bristles arising slightly beyond the middle, less than half as long as length of shaft beyond point of insertion; plate of anal segment without hair tufts along the mid-ventral line, or with only one or two minute hairs ..... *perturbans*

   Antenna with a pair of long bristles arising beyond middle, their tips reaching tip of shaft; anal segment with several one- to three-branched hairs (precratal tufts) penetrating the plate along the mid-ventral line, more than half as long as the diameter of segment 2

2. Comb scales rounded, fringed with stout subequal spinules .. *indubitans*

   Comb scales long, thornlike, sparsely fringed with fine spinules on basal half ..... *titillans*

MANSONIA INDUBITANS Dyar and Shannon

This species was first recorded in the United States from larvae and pupae collected on waterlettuce at Boca Raton, Fla., in 1944 (*249*). The adults are very similar to those of *M. titillans* and previous identifications of this species undoubtedly included specimens of *indubitans*. A half-dozen specimens in the writers' collection, formerly identified as *titillans,* are all *indubitans*. The latter has proved to be the more numerous and more widely distributed of these two species in Florida. Collections recorded by Chamberlain and Duffey (*70*) of material from seven localities across the State in southern Florida gave a total of 862 *indubitans* vs. 218 *titillans*. The principal host plant normally is waterlettuce, *Pistia stratiotes,* but in Florida the larvae have been reported also in small numbers on pickerelweed, arrowhead, and waterhyacinth (*283*). No information is available as to where the egg-rafts are deposited, or whether or not they are attached to the leaves of the host plant as in the case of *M. titillans*.

The females readily attack man and domestic animals. Both sexes are attracted to light traps. At Leesburg, Fla., where *M. perturbans* and *indubitans* are both prevalent, a series of comparative collections by different methods over a period of 48 nights in October and November 1954, gave the following total females of the two species (*258*) :

Method of Collection	*Number*	*M. indubitans*	*M. perturbans*
Truck trap	444	1,883	3,971
Light traps	111	3,846	495
Goat-baited trap	6	10	1,779
Calf-baited trap	45	358	6,212
Man-biting collections	288	590	742

The truck trap consisted of a large screened funnel having a rectangular opening 2 × 8 feet, mounted on the cab of a small truck that was driven about the test area for a distance of about 2.7 miles per collection; 12 collections were made per night before midnight. This trap was considered to give the best estimate of the true relative prevalance of the different mosquitoes. The light traps and animal traps were run all night, and there were twelve

biting collections per night during the period the truck trap was operated. It is noted that *indubitans* was relatively much more attracted to light traps and somewhat more so to man, but much less attracted to goat and calf. The ratio of the total mosquitoes biting man to the total in the truck trap was 0.31 for *indubitans* compared with 0.12 for *perturbans*.

In previous light-trap collections in the same locality during 1949, a great preponderance of *indubitans* was taken (*257*) but, as indicated above, this was probably a matter of relative attractiveness rather than actual predominance. Light-trap collections in Lee County in southwestern Florida likewise showed more *indubitans* than *perturbans* (*286*). Development of *Mansonia* larvae is extremely slow in comparison with that of other kinds of mosquitoes, and there is thought to be only a single annual generation, as a rule. In the light-trap collections at Leesburg (*257*), *indubitans* showed a peak in September, with a secondary peak in April. Whether these represented two generations or only different broods could not be determined, but it seems most likely that two generations occur. Some adults were collected every month.

In addition to collections of *indubitans* in south and central Florida, records of the Florida State Board of Health show its occurrence in northern and western parts of the State from Duval County to Escambia County at the extreme northwestern tip (*53*). There is a record of one female collected in a light trap at Camp Stewart, Hinesville, Ga., in 1945 (*230*). Nineteen adults, one alive, were recovered from planes arriving in Miami in 1938 (*322*). The species has not been reported from the Florida Keys. Its range includes the Caribbean region, Mexico, and northern South America.

ADULT.—Proboscis and palpi speckled with white, the proboscis with a narrow median white ring, the palpi about one-fourth as long as the proboscis. Occiput with a triangular patch of pale narrow scales. Mesonotal scales brown and yellowish intermixed. Postspiracular bristles present. Wing length 3.5 to 4 mm. The scales are very broad, speckled with white. Femur, tibia, and first tarsal segments well sprinkled with white, the tarsal segments all with basal white rings except the last segments of the fore and mid feet. Abdominal segments with apical white bands; segment 8 retracted, the tip of the tergite with a double row of stout, pointed spines, evenly spaced (usually require dissection to be seen); segment 7 without apical spines. In the male the dististyle is greatly enlarged basally, with a finger-like projection, and the apical half is somewhat twisted, or convoluted. The basal lobe of the basistyle is long and slender, with a stout spine at tip.

LARVA.—Antenna very long and slender with a large tuft at about the basal third and two long bristles beyond the middle extending beyond the tip of the shaft. Upper and lower head hairs small, multiple. Lateral spine of maxilla serrate on one side. Comb of about 10 uniform scales in an even row, each rounded and fringed with fairly coarse spines, the apical one less than twice as long as the next pair. Air tube stout, pointed, adapted for piercing the roots or stems of aquatic plants, with a small multiple lateral tuft toward the base and two stout dorsal bristles toward the tip; pecten lacking. Anal segment longer than wide, ringed by plate, with a row of four single or double hairs inserted in the plate on the mid-ventral line. Gills about as long as the width of segment.

MANSONIA PERTURBANS (Wlk.)

As in other species of this genus, *M. perturbans* has very broad wing scales, mixed brown and white. The proboscis and tarsi are

ringed with white. Breeding takes place in marshes and lakes having a thick growth of emergent aquatic vegetation. Larval development is extremely slow, and the winter is passed in this stage. The pupal period is also long for mosquitoes, lasting 5 or 6 days or more. In northern localities larvae have been found associated with such plants as cattail (*Typha*), aquatic sedges (*Carex*), pickerelweed (*Pontederia*), et cetera. At Seashore State Park, Va., the principal host plant was arrowhead (*Sagittaria*) (*90*), and in New Jersey the egg rafts were found associated with clumps of tussock sedge (*Carex stricta*). In the Lake Apopka area in central Florida, the principal host plant was the common pickerelweed (*Pontederia cordata*) (pl. 9, *B*). In this area and in the upper St. Johns River basin, larvae were also obtained from the following plants, named in the approximate order of importance (*211*): Cattail (chiefly *Typha latifolia*), frogbit (*Limnobium spongia*), waterlettuce (*Pistia stratiotes*), arrowhead (*S. lancifolia* and *S. montevidensis*), spatterdock (*Nymphaea macrophylla*) and water-hyacinth (*Piaropus crassipes*). In the vicinity of Leesburg, Lake County, only a short distance from the Lake Apopka area, sawgrass (*Mariscus jamaicensis*) was the predominant plant in margins of the lakes, and was the principal host plant for *perturbans* larvae (*27*). Other host plants in order of importance were lizardtail (*Saururus*), arrowhead, swamp loosestrife (*Decodon*) and pickerelweed. About 12 other species of plants, including waterlettuce and water-hyacinth, were listed as occasional hosts. Water-hyacinth, although noted also as a host plant in Palm Beach County, Fla., (*283*), fortunately is not a very favorable host; otherwise, these mosquitoes undoubtedly would be much more widely distributed and abundant in the extreme South, where the hyacinth covers large areas of lakes, bayous, and canals.

Throughout most of its range this species has a single generation each year, a large proportion of the adults emerging over a comparatively short period in the late spring and early summer. On Cape Cod, 85 percent of the larvae were in the fourth instar by the end of October, but remained in this stage over winter. In the vicinity of Lake Apopka, Florida, the adults were present from March to December, with a peak in May or the last of April, and a secondary peak the first part of August. In rearing experiments at Orlando, practically all the larvae that were hatched in the spring reached the fourth instar and some emergence occurred in about three months. At Leesburg, Fla., light-trap collections in 1949 showed a peak in May and a slight rise in August (*257*). It appears therefore that a partial second generation occurs in this area. Methods for collecting the larvae and pupae have been described in the discussion of the genus.

M. perturbans is an important pest species in many areas where breeding conditions are favorable. The females bite readily during the daytime in shady, moist places, but the main flight takes place during the half hour just before and after dark. Following this dispersion they are more active in the early part of the night than later. Comparative records of the collection of adult females by different methods are given in the discussion of *M. indubitans*. At Leesburg, Fla., *perturbans* was attracted to light traps and to man relatively much less than *indubitans*, but much more so to

goat and calf (*258*). Collections near Orlando, Fla., showed nearly three times as many mosquitoes biting on man as were taken in a light trap during comparable 15-minute collections (*50*). The females fly considerable distances from the breeding places. They were caught in light traps in several locations in Delaware Bay, one of which was 8 miles to the nearest shore and 12 miles to the farthest shore; another location was about 8 and 10 miles from shore. Six of 105 specimens were males (*209*).

The species has been recorded from all the Southeastern States and throughout most of the rest of the United States, as well as southern Canada and Mexico. It occurs also in Europe.

The virus of eastern equine encephalitis has been recovered from specimens collected in Georgia (*164, 197*). Thus, *perturbans* must be considered a probable vector of the disease. Its vector potential for EEE was rated as "good" (*72*).

ADULT.—Proboscis, thorax, and legs well speckled with brown and white scales. Proboscis with a wide median white ring. Spiracular and postspiracular bristles absent. Wing scales very broad, mixed brown and white. Wing length about 4 mm. Tarsal segments all with broad white basal rings and a broad ring in the middle of each of the first segments; hind tibia also with a wide white ring toward the tip. Abdominal segments with basal lateral pale spots and sometimes with narrow basal bands. In the male, the dististyle is enlarged apically but not basally. Basal lobe of basistyle short, with a stout rounded rod and a slender spine at apex.

LARVA.—Antenna very long and slender, with a large tuft at the basal third and two small bristles beyond the middle extending less than halfway to the tip of the shaft. Lower head hair long, multiple; the upper, shorter, also multiple. Lateral spine of maxilla smooth. Comb scales in a single irregular row, each long, thornlike, finely fringed on the sides. Air tube without a pecten, the tip bluntly pointed, heavily sclerotized, and with sawteeth on one side for piercing the roots and stems of aquatic plants; a long multiple lateral tuft about the middle of the tube, a stout dorsal bristle and a slender subdorsal one. Anal segment longer than wide, ringed by the plate, without hair tufts piercing the plate along the midventral line or with only one or two minute hairs. Gills about as long as the width of the segment.

MANSONIA TITILLANS (Wlk.)

This tropical species is found in the United States only in Florida and Texas. It is very similar in habits as well as appearance to *M. indubitans*, and the two were formerly confused in Florida. As with *indubitans*, its principal host plant is waterlettuce but larvae have been taken exceptionally from pickerelweed, arrowhead, and water-hyacinth (*283*), and are said to attach also to the roots of a floating grass, *Paspalum repens* Berg (*96*). In the lower Rio Grande Valley of Texas, where the species is common, waterlettuce is reported to be scarce. Here the larvae were constantly associated with water-hyacinth and less frequently with cattail (*100*). They were easily collected from the water-hyacinth by lifting a plant quickly into a pan of water.

Little is known of the biting habits of *M. titillans* in Florida, but in Texas it bites viciously and was second only to *Psorophora confinnis* in annoyance to humans (*100*). In Panama, *titillans* is abundant and an important pest species in some locations. It was the most ubiquitous species in the Gatun Lake area (*92*). Adults were found throughout the year. The females dispersed from the forested areas at night and were aggressive biters, attacking various kinds of mammals. Under natural conditions the eggs

were attached to the under surface of the leaves of waterlettuce. The species has not been reported from other host plants there.

Identifications of *M. titillans* in Florida prior to 1945, when *M. indubitans* was first recognized in the State, undoubtedly included both species. Subsequent records showed it to be actually less numerous than that species when the two occurred together (*70*), and it is much less widely distributed. Most of the specimens recorded by these authors were from Boca Raton and West Palm Beach in Palm Beach County, with smaller numbers from Martin and Highlands Counties. It has been recorded additionally from Lee, Okeechobee, and Hendry Counties, and the southern Atlantic coast counties from Brevard to Dade (*53*). The species is known from southern Texas, Mexico, the Caribbean region, and South America.

ADULT.—This species is very similar in general appearance to *M. indubitans* and difficult to distinguish except by the distribution of the spines at the tip of the seventh and eighth tergites of the female, and by slight differences in the female palpi and the male gentalia. In *titillans*, on segment 8, there is an apical median row of about eight closely set, toothlike spines with rounded tips, and a separated group of spines on each side, some rounded and some bluntly pointed. In *indubitans* the spines are in two regular rows, the apical row longer, the spines more widely spaced than in *titillans*, and with all the spines pointed. Tergite 7 has a close-set marginal row of stout pointed spines, which is lacking in *indubitans*. These can be seen quite readily with the microscope without dissection. In the male the base of the dististyle is less enlarged and the apical half is not twisted.

LARVA.—The larvae of the two species are also very similar except in the shape of the comb scales, which in *titillans* are long, slender, and thornlike, with the apical spine much longer than the weak lateral spinules. The comb consists of six to eight scales, which show a distinct increase in size from one side to the other.

Genus ORTHOPODOMYIA Theobald

The mosquitoes of this genus breed in water in tree holes and occasionally in artificial water containers. The eggs are laid singly at the water's edge (*163*) or on the water surface (*157*), and hatch in 2 or 3 days. Two species are found in the Southeastern States and these are very difficult or impossible to distinguish with certainty except in the larval stage. A review of their habits, distribution, and distinguishing characters has been given by Jenkins and Carpenter (*174*). Neither species is known to be of any importance to man.

The females of this genus have short palpi; the males have long palpi and bushy antennae. Spiracular and postspiracular bristles are lacking, the posterior pronotum has two to five bristles, the scutellum is trilobed, and segment 4 of the fore tarsus is very short, only slightly longer than wide. The tip of the female abdomen is bluntly rounded, the eighth segment not retracted. The species are of medium size, mottled black and white, and can be recognized immediately by the fine, longitudinal lines of silvery scales on the mesonotum. The male dististyle is slender, the claw long and frayed at the tip, the basistyle with a conical basal lobe bearing both slender and stout bristles. A claspette is lacking, the tenth sternite has a few apical teeth, the phallosome plates are stout, tapered, joined apically, slightly serrate on outer margin toward the tip. The larvae are *Aedes*-like in appearance, with

small antennae and a single pair of ventro-lateral tufts on the air tube. The air tube lacks a pecten, however, and the comb scales are in two unequal rows, one composed of short-fringed scales, the other of very long thornlike scales.

KEY TO SPECIES

LARVAE (FOURTH INSTAR)

1. Segment 8 of abdomen with a large sclerotized dorsal plate, a similar but smaller plate usually present on segment 7 and frequently on 6; tuft of air tube very large, with five to twelve branches ..... *signifera*
   Abdominal segments without sclerotic plates; tuft of air tube small, not longer than diameter of tube, usually three- or four-branched ..... *alba*

ORTHOPODOMYIA ALBA Baker

This species is very similar in appearance to *O. signifera,* and the two can be recognized immediately by the fine white lines on the thorax. *O. alba* has been collected in tree holes in several different kinds of trees and occasionally also in artificial water containers such as a flower pot (*140*), and a carbide cannister (*281*). It has almost always been associated with larvae of the closely related species *O. signifera* (*174*), but is much less commonly encountered. *A. triseriatus* has also been found with it. Nothing apparently is known of the feeding habits of the adults.

The species was found to overwinter in New York as larvae frozen in the ice (*213, 5*), but in Texas it was thought to overwinter in the adult stage as no larvae were found between November and April, and dry material from the summer tree-hole habitats during this period failed to produce larvae. Larvae frozen in tree-hole water in a refrigerator from two hours to two days failed to survive (*326*). These authors found the larvae in only a small percentage of the tree holes. The majority of breeding holes had openings not more than three inches in diameter, part of them barely one-half inch wide. The larvae were found at one time or another associated with *O. signifera, A. triseriatus,* and *Toxorhynchites r. septentrionalis.* They often occurred in the absence of *O. signifera.* The pH of the water ranged from 7.6 to 8.4. Larvae were not obtained by flooding dry material from the holes and none was found less than a week after the cavities had been filled, indicating that the species survives periods of drought as adults.

Although rare, the species has been recorded in scattered localities over a wide range extending from New York to Missouri and Texas. It was originally described from near Ithaca, N. Y. (*5*), and was first recorded in the South from Colbert County, Ala. (*289*). Since then, it has been reported from several localities in North Carolina (*47, 174*), Mississippi (*228, 225*), New Orleans, La. (*243, 140*), and Atlanta, Ga. (Stone, personal communication). There were other reports from North Carolina, Mississippi, and Panama City, Fla., in 1944 (*66*) and from Hinesville, Ga., in 1944 (*230*), based on light-trap collections, each with only one female. In view of the uncertainty of the identification of adults,

these records must be regarded as doubtful until confirmed by larval determination.

ADULT.—Almost identical in all characteristics with *O. signifera* except for slight differences in coloration of abdominal segments 1 and 2, which are given in the description of that species. These differences were found to be fairly consistent in reared specimens in North Carolina (*281*) but were said to be unreliable in other areas studied (*174*). A key to the adults has therefore been omitted.

LARVA.—Differs rather markedly from those of *signifera*, the most obvious difference being the lack of sclerotized plates on abdominal segments 6 to 8, which are present in the latter. Upper and lower head hairs multiple, equal in size. Outer sutural hair large, multiple; the inner, single. Comb scales in two dissimilar rows, the posterior one of about ten very long, thornlike scales, the anterior row of 11 to 18 much shorter scales, part of which are thornlike and part fringed apically. Air tube about 3:1, pecten lacking, tuft shorter than diameter of tube, with only three to five branches. Anal segment faintly or incompletely ringed by the plate, the lateral hair double or triple. A very small elongate sclerotized plaque near base of segment. Gills quite short, the ventral pair shorter than the dorsal pair. The larvae are of whitish color compared with the reddish color of *signifera*. Breland (*55*) has described variations found in *alba* larvae.

ORTHOPODOMYIA SIGNIFERA (Coq.)

This species breeds chiefly in the water in decayed holes in many kinds of trees, and is also found at times in artificial water containers. It is associated more or less frequently with *Aedes triseriatus, Toxorhynchites* sp., and *Anopheles barberi,* as well as *O. alba*. The eggs may be laid on the edge of the water container close to the water line (*163*) or on the water surface (*157*). Eggs deposited on the edge of a beaker in the laboratory hatched in three days (*174*). The larvae are said to be unable to withstand freezing (*5*). Thibault (*303*) reported it as being abundant near breeding places in Arkansas and as entering houses to bite, an observation that has not been confirmed elsewhere, although there are a few reports of an occasional biting female. Females starved in captivity would not attempt to bite an arm, although both sexes readily fed on honey (*174*). The females could not be induced to feed on rabbits, hamsters, chickens, frogs, or turtles, and it was thought that the clear liquid usually found in the gut might be nectar, honey, or the haemolymph of some invertebrate. They could be kept alive for over forty days on raisins (Snow, quoted by Horsfall (*160*)).

O. signifera is widely distributed in the Southern and Eastern States from Massachussetts to Nebraska and Texas. It has been found also in several localities in California. It was previously reported from all of the Southeastern States (*193*).

ADULT.—Proboscis unringed, with fine longitudinal lines of white scales, the palpi also white-lined. Mesonotum with four pairs of fine longitudinal white lines, one submedian pair extending two-thirds of the way back, one pair extending completely around the lateral margin, and two shorter pairs posteriorly, the submedian pair running across the prescutellar space and onto the midlobe of the scutellum. Wing length 3.5 to 4 mm., the scales broad, mixed brown and white, a spot of white scales running across the veins from the stem of vein 2 to 5.1 and another all-white spot on the basal third of the anal vein. Femora and tibiae sprinkled and lined with white scales, the hind tarsi with broad apical and basal bands on segments 1 to 4, segments 5 all white, fore and mid tarsi with slight markings on the first two segments. Segment 1 of abdomen typically with a large central patch of white scales, the integument brownish in color, segment 2 with a wide basal band, not extending to the posterior margin, the other seg-

ments with large basal lateral spots and usually with narrow basal bands. *O. alba* was described as having the integument of segment 1 of a yellowish color and segment 2 almost entirely white-scaled, the white extending to the posterior border in the middle. As mentioned under that species, however, these differences do not appear entirely reliable and identification must depend upon the larvae.

LARVA.—Antennal hair multiple, inserted before middle of shaft. Upper and lower head hair long, multiple, equal in size. Both sutural hairs single. Lateral hair of abdominal segments 1 and 2 comparatively short, multiple. Segment 8 with a large dorsal sclerotized plate, a smaller one usually present on segment 7 and a much smaller one often present on 6. Comb scales in two rows behind the plate, the posterior row of 8 to 10 very long thornlike scales, the anterior row about 17 to 24 much shorter scales, part of which are thornlike, the others (on the ventral part of the row) rounded and fringed apically. Air tube about 3:1, pecten lacking, the ventral tuft multiple, much longer than diameter of tube, inserted near middle. Anal segment ringed by plate, the lateral hair single; a small elongate sclerotized plaque near base of segment. Dorsal pair of gills about as long as the plate, the ventral pair shorter. The larvae have a reddish coloration.

Genus PSOROPHORA Robineau-Desvoidy

Most of the species of *Psorophora* are severe biters, and at least one of them (*P. confinnis*) is an important economic pest. The breeding habits of the group are similar to those of the typical *Aedes*. The eggs are adapted to withstand drying and may lie dormant on the soil of breeding sites for long periods. They hatch upon being flooded, and the larvae may complete their development in very transient pools, as they develop very rapidly. The larvae of two of the species (subgenus *Psorophora*) are predaceous upon other mosquito larvae and are therefore of some benefit to man, but the females of these two species, the familiar gallinippers, are themselves avid bloodsuckers.

This genus is closely related to *Aedes* from which it is separated by the presence of spiracular bristles. The white scaling on the abdomen is apical instead of basal, unless the tergites are entirely white-scaled. The female abdomen is pointed and the eighth segment retractile as in *Aedes*. In the male the basistyle is without lobes. Claspettes are present and vary greatly in shape between the different species. The anal segment of the larva is completely ringed by the plate and a row of hair tufts penetrate the plate on the midventral line. The eggs of seven species have been described by Horsfall *et al.* (*161*).

The twelve southeastern species of this genus are divided into three subgenera as follows: (*Psorophora*) *ciliata* and *howardii;* (*Grabhamia* Theob.), *confinnis, discolor, pygmaea,* and *signipennis;* (*Janthinosoma* L.-Arr.) *cyanescens, ferox, horrida, johnstonii, longipalpis,* and *varipes.*

The species of subgenus *Psorophora* are very large and are known in some areas as gallinippers. The mouth brushes of the larvae are modified to form stout prehensile hairs for grasping and holding their prey (fig. 16, *D*), each of the hairs being hooked at the tip, and with a row of comblike teeth along the side. The ventrolateral hair of the air tube is long and single and the spines of the pecten are numerous and bristlelike.

In subgenus *Grabhamia* the proboscis and tarsi are white-ringed, the scales of the mesonotum are narrow-curved, the wing and leg scales are mixed brown and white, at least the hind femur

has a narrow white ring toward the apex, and the female claws are simple. The larvae have normal, ciliate mouth brushes, the ventrolateral hair of the air tube is multiple and usually very small, and the pecten spines are few and stout so that the larvae are easily distinguished from subgenus *Psorophora*.

In subgenus *Janthinosoma* the proboscis is not ringed with white, the mesonotum has some broad, pale scales, the wing scales are all dark, the legs and abdomen are blue-black in color, the white markings on the tarsi are restricted to one or more of the last three segments of the hind feet (in one species, *P. cyanescens*, the tarsi are all dark), and the female claws are toothed. The larvae of this subgenus are not easily separated from those of *Grabhamia* except by specific characters.

KEY TO SPECIES

ADULTS

1. Legs shaggy, with long erect scales or with tufts of erect scales toward tips of hind femur and tibia; very large species of striking appearance (fig. 2, *B*). The gallinippers ..... Subgenus *Psorophora*. 2
   Legs not markedly shaggy and species not exceptionally large 3
2. Mesonotum with a median stripe of golden scales (fig. 19, *H*); proboscis and tarsi with white rings; general color yellowish .. *ciliata*
   Mesonotum with a wide median stripe of dark scales; proboscis not ringed; first two segments of hind tarsi usually with very narrow, pale basal rings; general color bluish ..... *howardii*
3. Proboscis and tarsi ringed with white; legs and wings with mixed black and white scales; hind femur with a very narrow ring of white toward apex ..... Subgenus *Grabhamia* 4
   Proboscis not ringed with white; tarsal markings restricted to one or more of the last three segments of hind feet, or entirely dark; hind femur not ringed. Bluish *Psorophora* ..... Subgenus *Janthinosoma* 7
4. First hind tarsal segment dark except for a narrow basal white ring. Florida Keys ..... *pygmaea*
   First hind tarsal segment ringed at base and in middle, or largely pale 5
5. Wings without well-defined spots or areas of white scales; first hind tarsal segment ringed with white in middle and at base. A fairly large, blackish species, common in the Southern States ..... *confinnis*
   Costa and veins with well-defined spots or areas of pale scales; femur and first hind tarsal largely pale-scaled, intermixed with dark, and ringed with dark scales apically 6
6. Wing costa with a spot or stripe of pale scales at base and one opposite tip of subcostal vein; fringe spots lacking. Usually rare southern species ..... *discolor*
   Apical half of costa with two white spots, none at base; pale fringe spots present opposite the tips of all veins. Recorded only from Arkansas and Tennessee in the Southeast ..... *signipennis*
7. (3) Tarsi all dark; abdominal segments with apical, oblique, submedian patches of pale scales ..... *cyanescens*
   Hind tarsi marked with white on the apical segments; abdominal segments with only lateral apical pale spots 8
8. Fourth segment of hind tarsus white-scaled dorsally, the fifth segment dark 9
   Last two segments of hind tarsus white 10
9. Mesonotum with a wide median longitudinal stripe of dark scales, broad yellowish-white scales laterally (fig. 19, *G*). Found in all Southeastern States ..... *varipes*
   Mesonotum clothed completely with yellowish-white scales. Florida Keys ..... *johnstonii*

10. Mesonotum clothed with a mixture of brown and broad whitish scales. Common woodland species, the white-footed mosquito .... *ferox*
Mesonotum with a broad median stripe of dark scales, whitish scales laterally 11
11. Tips of femora white-scaled (knee spots); palpi of female less than one-third length of proboscis. Throughout Southeast, usually rare ..... *horrida*
Knee spots absent; female palpi more than a third as long as the proboscis. Western Arkansas and Louisiana, rare ..... *longipalpis*

LARVAE (FOURTH INSTAR)

1. Mouth brushes formed of stout prehensile hairs (fig. 16, *D*), each hooked at tip and with a row of comblike teeth along the side; pecten with the spines prolonged into hairs. Very large predaceous larvae 2
Mouth brushes normal, ciliform; pecten not as above 3
2. Lateral hair of anal segment with three or four branches from base ..... *ciliata*
Lateral hair of anal segment single or forked some distance from base ..... *howardii*
3. Antenna very long, somewhat inflated beyond middle, two long bristles at outer third in addition to the large central tuft; air tube small with a paired tuft of very long hairs ..... *discolor*
Antenna not as above; air tube large, more or less inflated, the ventral tuft usually small or obsolete 4
4. Upper and lower head hairs both multiple ..... *confinnis*
Head hairs single or double, rarely triple 5
5. Upper and lower head hairs single; antenna normal, shorter than head 6
Upper head hair double, the lower double or triple; antenna unusually long, distinctly longer than head in most species 8
6. Antennal tuft with many branches, and preantennal tuft with at least six ..... *signipennis*
Antennal and preantennal tufts with less than six branches each 7
7. Tip of air tube with a pair of long hairs on the lateral valves; pecten with 3 or 4 spines, each with a single basal tooth .... *cyanescens*
Hairs on lateral valves of air tube short, less than the diameter of the tube at its tip; pecten of 5 or 6 spines, each with several teeth at base ..... *pygmaea*
8. (5) Lateral abdominal hairs minute on segments 4 to 6; spines of pecten with several teeth, subequal in size, on one or both sides at base ..... *horrida*
Lateral abdominal hairs long enough to be readily seen; spines of pecten with one fairly strong tooth on one or both sides at base and usually one or two much smaller teeth 9
9. Lateral abdominal hairs single or double on segments 4 to 6 10
Lateral abdominal hairs multiple on segments 4 to 6 11
10. Antenna unusually long, nearly 1.5 times as long as head ..... *ferox*
Antenna only slightly, if any, longer than head ..... *varipes*
11. Lateral hair of anal segment branched near base; pecten usually with 6 to 8 spines ..... *johnstonii*
Lateral hair of anal segment branched toward tip; pecten with 3 or 4 spines ..... *longipalpis*

PSOROPHORA CILIATA (F.)
(The Shaggy-Legged Gallinipper)

This is a very large mosquito (fig. 2, *B*) of a general yellowish-black color, and with very shaggy legs. The larvae occur in temporary rain pools or other flooded areas and, since they are most often associated with larvae of *Psorophora confinnis*, their breeding places are the same; that is, in grassy ditches, pools, and shallow grassy flats of all sizes, ricefields, the Florida Everglades, et cetera. They are predaceous on other larvae, but, although each

individual destroys a good many victims, they seldom occur in large enough numbers to give an appreciable degree of control. Several generations may occur each year depending on suitable conditions of alternate drying and flooding of the breeding places. Various other species of *Psorophora* and *Aedes,* including the fellow predator, *P. howardii,* often occur in the same breeding places. Breland (*56*) reported that the larvae totally disregarded adults and larvae of the fruit fly *Drosophila,* when offered as food in the laboratory, although *Toxorhynchites r. septentrionalis* showed a more decided preference for the fruit fly adults when placed on water surface than for other mosquito larvae.

The adults are severe biters and, because of their large size, rather frightening in appearance. They seem to be strong fliers and are encountered at considerable distances from the breeding places, usually mixed with large numbers of *P. confinnis.* Because of the relatively small numbers, they are not considered a major pest.

This species has previously been reported from all the Southeastern States (*193*). Its range includes the Eastern and Midwestern States, southern Canada, and parts of Mexico, Central, and South America.

ADULT.—Proboscis with a median white ring and speckled with white toward tip. Palpi about a third as long as the proboscis. Mesonotum with a median stripe of narrow golden scales running the full length, and lateral areas or stripes of broad white scales, the median and lateral stripes separated with nude stripes and narrow dark scales. Wing length about 6.5 to 7 mm., the scales dark. White basal rings present on all the tibiae, all segments of the hind tarsi, and segments 1 to 3 of the fore and mid tarsi; the legs, especially the hind pair, with long, dense, erect dark scales on the apical part of the femur and most of the tibia and first tarsus. Abdominal segment 1 with a median patch of whitish scales, the rest of the tergites almost entirely pale-scaled.

LARVA.—Mouth brushes modified for grasping, as described previously. Antennal hair very small, single, inserted toward apex. Lower head hair fairly long, the upper much shorter, both branched three or four times beyond the middle. Comb, an even curved row of long, thornlike scales. Air tube about 3.5:1, the sides nearly straight, the ventrolateral hair long, single, inserted beyond the pecten, the pecten spines unusually long and bristlelike. Anal segment ringed by the plate, which is penetrated by tufts of the ventral brush; lateral hair short, multiple, branched near base. Gills long, pointed, about twice the length of the segment.

PSOROPHORA CONFINNIS (L.–Arr.)

(Syn., *P. columbiae* (D. and K.), *Janthinosoma floridense* D. and K., *Culex jamaicensis* of Dyar, in part (not of Theob.), etc.; the Florida glades mosquito)

The Florida glades mosquito, long known as *Psorophora columbiae,* is above medium size and of a sooty black color. The proboscis and tarsi are white-ringed, the first hind tarsal segment has a white ring in the middle and the abdomen has diffuse apical pale scaling or large apical patches. It breeds in temporary pools and occurs commonly throughout the Southeast. The species becomes a major pest in the region surrounding the Florida Everglades as well as in the rice-growing areas of Arkansas and Louisiana where it is sometimes called the ricefield mosquito. Other than heavily shaded woodland pools, the larvae are found in many types of places, but particularly in grassy ditches, open grassy

swales, ricefields and their ditches, flooded pastureland, et cetera. They occur frequently in almost pure culture, except for the presence of their predators *P. ciliata* and *howardii*, but are also found on occasion with a variety of other species of *Psorophora* and *Aedes*.

In Tennessee it was taken at one time or another with 12 different species, most frequently with *Aedes vexans*. Larval development is rapid, requiring only 4 or 5 days in warm weather, so that adults may apear in less than a week after the eggs are flooded (*290*). Alternate drying and flooding of the breeding sites may produce several generations annually. The winter is passed in the egg stage.

In Arkansas the drained ricefields comprised the greatest acreage suitable for oviposition, while pastures and ditches were also selected when conditions were suitable (*159*). Larvae were less abundant in the ricefields when first flooded than after the cultural drainage and reflooding in midsummer, when enormous numbers were to be found. Comparative counts of larvae were obtained with the aid of a screen cylinder having a cross-section area of 1 square foot. This was placed upright with the lower end settled in the mud, and the larvae were dipped out with a tea strainer. Schwardt (*282*) found most of the early season breeding in ditches, canals, seepage puddles, and places other than the ricefields on the first flooding. The larvae were sometimes found in numbers following the midseason flooding, but this did not appear to be the rule. Schwardt stated that *P. confinnis* comprised about 90 percent of the mosquito population in the rice region, the remaining 10 percent consisting of *Anopheles quadrimaculatus, Psorophora discolor,* and *P. ciliata.*

The females attack at night or in grassy or shady places during the day. They are not as aggressive as the salt-marsh *Aedes* except when a large brood appears. In the Everglades the species occasionally appears in enormous swarms and, according to McNeel, as cited by Bishopp (*30*), has caused large losses of livestock by its attacks. During these outbreaks it is almost impossible for humans to remain out of doors at night or in sheltered places during the day without some protection. Workers in sugarcane fields sometimes carry smudge pots for this purpose, and large smudges are employed for the relief of stock. The females disperse over huge areas and reach both coasts in large numbers. They also appear in enormous numbers in the ricefield areas of Arkansas, and are extremely annoying to livestock, especially cattle (*159*). Identification of blood meals by the precipitin method in 479 engorged females in Arkansas gave positive reaction for bovine blood in 69 percent; swine, 16 percent; horses, 14 percent; and man, less than 1 percent (four specimens) (*324*).

In a study of the biology of *P. confinnis,* Horsfall (*159*) found an average preoviposition period of 8 to 9 days, with three blood meals normally consumed during this period. One meal was not sufficient to mature the first batch of eggs. In experiments on the distance of flight, stained specimens were recaptured up to about 9 miles from the point of release. *P. confinnis* and *P. discolor* were captured in about equal numbers, and the two constituted about 95 percent of the total mosquitoes. Most of the

others were *Anopheles quadrimaculatus* and *Culex erraticus*. *P. confinnis* occurs throughout the United States and its range extends into Mexico, parts of the Caribbean region, and South America. In most of the southeastern area *P. confinnis* seldom occurs in large numbers and is considered only of minor or local importance.

ADULT.—Proboscis with a wide, median white ring. Palpi about a fourth as long as the proboscis, white-tipped. Mesonotum clothed with narrow black scales, well sprinkled or frosted with white. Prescutellar space circled with pale scales. Lobes of scutellum pale-scaled. Wing length about 4.5 mm., the scales mixed white and black, the white not segregated into discrete spots. Femora and tibiae speckled with white, the femora with narrow subapical white rings and white knee spots; hind tarsi with wide basal rings and a wide ring in the middle of segment 1, the fore and mid tarsi similarly marked except that segment 5 is all dark. Abdomen with large apical triangular patches on segments 2 and 3, and with diffuse scaling or separated submedian, apical patches on segments 4 or 5 to 7.

LARVA.—Antennal hair and upper and lower head hairs large and multiple. Comb, a single row of about six scales set on the posterior border of a small sclerotized plate, the single scale stout, rounded, with a long central spine and much shorter lateral spinules. Air tube about 3:1, slightly swollen, with a moderately large, multiple tuft inserted beyond the middle; pecten of only four or five spines. Anal segment ringed by the plate, with tufts of the ventral brush penetrating the plate. Gills pointed, about twice as long as the segment.

PSOROPHORA CYANESCENS (Coq.)

This blue-black *Janthinosoma* is the only local *Psorophora* in which the tarsi are entirely dark. It is rare in most of the Southeastern States, but was reported as very abundant and annoying at times in Arkansas (*303*). It was reported to be the most abundant *Psorophora* in the Muscle Shoals area, Alabama (*287*), and to be locally abundant as a pest in Mississippi (*245*). The larvae occur in transient pools associated with other species of *Psorophora* and *Aedes*. Larval development is very rapid and was found to average 4.6 days from hatching to adult emergence in Arkansas (*282*). One breeding place cited by this author was a pool containing suspended clay and nearly free of vegetation. Thibault (*303*) in Arkansas found *P. cyanescens* the most annoying of all mosquitoes when present in abundance, both to humans and stock, and to occur in fields, thickets, and about, but not inside, dwellings. It came out into the sunshine on the hottest days to bite. He said these mosquitoes never voluntarily quit biting and might travel for miles on horses and cattle. The species was reported to be comparatively rare in Tennessee. Larvae were collected only twice during the period from 1942 to 1945, both times in association with *Aedes vexans* (*290*). In Illinois, the females were said to make a characteristic high-pitched sound, and to attack by preference in bright sunlight rather than shade (*270*).

This species was previously listed for all the Southeastern States except Florida (*193*) and subsequently was collected at Tallahassee, Fla. (*230*). Records of the Florida State Board of Health show its occurrence in several other localities in the northwestern part of the State (*53*). Its range extends to Illinois and Nebraska, south to Texas, and New Mexico, and into Central and South America.

ADULT.— Proboscis and tarsi all dark. Mesonotum with broad, yellowish-white scales intermixed with lanceolate scales. Scutellar lobes with broad,

pale scales. Wing length about 4 mm., the scales dark. Dark scales of legs and abdomen with bluish reflections. Abdominal segments with curved apical white patches on each side of center, usually joined in the middle on the anterior segments to form a triangular patch.

LARVA.—Antenna somewhat shorter than the head with a small tuft of two or three branches, some of which may be redivided. Upper and lower head hairs long, single. Comb of only four stout scales on a weak plate, each with a long central spine and a stout subapical pair less than half as long. Air tube stout, inflated, about 2:1, with a minute multiple tuft beyond the middle and with two long hairs on the lateral valves, much longer than the apical diameter of the tube; pecten with only three or four spines, each with a single tooth at base. Anal segment ringed by the plate, which is pierced by tufts of the ventral brush. Gills with the dorsal pair longer than the ventral pair, and about three times as long as the segment.

PSOROPHORA DISCOLOR (Coq.)

This species is distinguished from other *Grabhamia,* except *P. signipennis,* by the presence of spots of white scales on the wings. The larvae occur in grassy ditches and pools, ricefields, and other sites similar to those in which *P. confinnis* is found. They have extremely long gills and apparently can remain submerged most of the time. They are said to come to the surface rarely until ready to pupate (*93, 159*). They lie on their backs on the bottom of the pool or cling to grass stems or debris by means of the anal tufts. Larval development requires 10 days or more, which is considerably longer than the time required for larvae of *P. confinnis* and *P. ciliata,* with which it is usually associated. In Tennessee, where the larvae were found to be fairly abundant, they were associated chiefly with *Aedes vexans* and *P. confinnis.*

The species occurs sparingly throughout the Southeast but was found in large numbers in the rice-growing areas of Arkansas, where it caused annoyance to man and livestock on a par with *P. confinnis* (*159*). It constituted 22 to 46 percent of all females caught in light traps during the summers of 1939 to 1942. It was taken in considerable numbers, chiefly as larvae, in Mississippi (*245*). Identification of the blood meals of 783 engorged specimens by means of the precipitin method, as reported by Whitehead (*324*), showed the following percentages with different kinds of blood: 73 bovine: 18 equine, 8 swine, 0.9 (7 specimens) human, and 0.4 avian.

P. discolor has been recorded from all the Southeastern States (*193*). Its range extends from New Jersey to Nebraska, and southwards to Texas, New Mexico, and into Mexico.

ADULT.—Proboscis with a broad white median ring, the palpi white-tipped. Mesonotum with fine brownish and golden scales. Wing length about 3.5 mm., the scales on some of the veins mixed dark and white; on others the white scales are segregated into distinct spots, one spot at the base of the costa, one at tip of subcosta, one in the middle of vein 3, one each in the middle of vein 4 and both forks of vein 5, and one covering the basal two-thirds of the anal vein; the wing fringe is without fringe spots. Femora, tibiae, and first tarsal segments predominantly pale-scaled, speckled with dark, the femora with narrow preapical white rings. The tibiae and first tarsal segments with a black apical ring, the other tarsal segments with broad basal white rings covering about half of the segments on the hind feet. Abdomen with a median, apical, white triangular patch on segment 1, the other tergites almost completely pale-scaled.

LARVA.—Antenna very large, S-shaped, with two long bristles at outer third, in addition to a large multiple tuft at basal third. Both upper and lower head hairs long and single, equal in length. Comb with about six

strong, thornlike scales set on the posterior border of a weak plate. Air tube unusually small, about 3:1, with a very large multiple tuft near middle, nearly as long as the entire tube; pecten of about six long spines. Anal segment ringed by the plate, which is penetrated by a few weak tufts of the ventral brush. Gills very long, five or six times as long as the segment, and with prominent tracheae.

PSOROPHORA FEROX (Humb.)

(Syn., *Janthinosoma sayi* D. and K., *Culex posticatus* Wied., *C. musicus* Say; the white-footed woodland mosquito)

P. ferox is one of the commonest of the blue-black *Janthinosoma*. The last two segments of the hind tarsi are pure white, and the thorax has dark and white scales intermixed. The larvae are found chiefly in temporary pools or depressions in woodlands, and sometimes in grassy pools or ditches at the edges of the tree growth. In southern Mississippi the larvae occurred in great numbers in puddles left by the overflow of Leaf River (*225*). They are often associated with *Psorophora varipes* and *Aedes vexans* in shaded pools. Several generations may occur during the summer, depending on the usual sequence of drying and flooding. The adult females become numerous and extremely annoying at times and, with the other species frequently associated with them, constitute a serious menace to man or animals entering their habitats. They feed during the daytme or night, and usually remain in or near the woodlands where they develop, but may leave the woods on occasion and even enter houses (*303*).

This species was previously reported from all the Southeastern States, and is known to occur generally through the East and Midwest, southeastern Canada, and Mexico; also in the Caribbean region, and South America.

ADULT.—Proboscis and palpi all dark. Mesonotum with mixed broad white and narrow brown scales, not forming stripes; fairly broad whitish scales around prescutellar space and on lobes of scutellum. Wing length about 4 mm., the scales all dark. Legs blue-black, the tarsi all dark except the last two segments of the hind feet and usually the tip of segment 3, which are white; white knee spots present on femora; first two tarsal segments and apical portion of tibia of hind legs with short, erect scales, but not nearly so shaggy as in *P. ciliata*. Abdomen blue-black with purplish reflections and with small apical, lateral white spots.

LARVA.—Antenna unusually long, about 1.5 times as long as the head, with a large multiple tuft inserted near the middle. Both upper and lower head hairs long, double, the lower sometimes triple. Comb with six or seven scales in a curved row set on a weak plate, each scale thorn-shaped with the apical spine much longer than the subapical pair. Air tube about 4:1, inflated, the tuft minute, multiple, the pecten with two to five spines, usually three or four, each with a stout tooth on one or both sides at base and one or two smaller spinules. Anal segment ringed by the plate, which is pierced by tufts of the ventral brush. Gills about 1.5 times as long as segment.

PSOROPHORA HORRIDA (D. and K.)

This comparatively rare species is similar in appearance to *P. ferox* but has a broad median stripe of dark scales on the thorax. There is almost no information available as to its habits in the Southeast. In Oklahoma, where it is not rare, it breeds in shaded temporary rain pools. The adults attack man readily (*275*). They were usually taken while biting with *P. ferox* in woods.

Specimens were collected at Marianna, Fla., in 1945 and 1950 (*230, 53*), and this completed the record of its occurrence in the Southeastern States. Its known range extends from Maryland to Ohio, Missouri, and Texas.

ADULT.—Proboscis and palpi all dark, the palpi less than a third as long as the proboscis. Mesonotum with a wide median stripe of narrow brown scales, bordered with broad white scales laterally and around the prescutellar space. Wing length about 4 mm., the scales all dark. Legs and abdomen blue-black. Femoral knee spots present, the tarsi all dark except the last two segments of the hind feet, sometimes also the tip of segment 3, which are white. Segment 1 of abdomen with a large white patch, the other tergites with only small lateral, apical white spots.

LARVA.—Antenna about as long as head or a little longer, with a large multiple tuft near the middle. Upper and lower head hairs short, the upper double, the lower double or triple. Lateral abdominal hairs minute on segments 4 to 6. Comb, a curved row of seven or eight scales, each thorn-shaped, with a fringe on each side of fairly strong subequal spinules. Air tube strongly inflated, about 3.5:1, the tuft minute, multiple, placed laterally; pecten with four or five spines, each with several subequal teeth on one or both sides at base. Anal segment ringed by the plate, which is penetrated by the tufts of the ventral brush. Gills bluntly pointed, about twice as long as the segment.

PSOROPHORA HOWARDII (Coq.)

(Howard's gallinipper)

This large species is similar in general appearance and habits to *Psorophora ciliata* and the two are commonly associated, although *howardii* adults, in the writer's experience, are usually of less frequent occurrence. The larvae are predaceous on other mosquitoes and have been reported to devour small polliwogs also. Breland (*56*) found that they disregarded larvae and adults of *Drosophila* when offered to them in the laboratory. He observed that the larvae used their modified mouth brushes to aid the mandibles in capturing their prey. The females attack in the day or night and are severe biters. They apparently fly considerable distances from their breeding places and are to be seen rather frequently in garages and shrubbery around urban residences. They perhaps disperse farther than *P. ciliata,* as they have been observed more often than that species in residential sections of Fort Lauderdale, Fla., in association with adults of *P. confinnis* that presumably had flown in from the farmlands and glades west of the city.

P. howardii has previously been recorded from all the Southeastern States (*193*), and occurs also from Maryland to Missouri and Texas, and into Mexico.

ADULT.—Nearly as large as *P. ciliata,* with a general bluish color. Proboscis unringed, palpi almost half as long as the proboscis. Thorax with a broad median stripe of dark narrow scales and nude lines, the lateral areas covered with broad white scales and similar ones around the prescutellar space. Wing length about 6 mm., the scales all dark. Legs much less shaggy than *P. ciliata,* the erect scales being limited mostly to the tips of the femora and tibiae; segment 2 of tarsi with a narrow basal white ring and a similar ring sometimes present on segment 1. Most of the abdominal tergites are pale-scaled laterally and apically.

LARVA.—Larval characters very similar to those of *P. ciliata* except for the lateral hair of the anal segment, which in the present species is rather long and is single or forked beyond the middle.

PSOROPHORA JOHNSTONII (Grabham)

This tropical *Janthinosoma* resembles *P. varipes,* with only the fourth hind tarsal white, but lacks the median dark stripe on the thorax. It was first collected on the Florida Keys in October and December 1945, when eight biting females were taken on Cudjoe Key, and one male was obtained from a light-trap collection (*232, 252*). Specimens previously collected on the Keys and identified as *P. varipes* (*193*) were probably this species. Larvae were first collected in December 1947 in a temporary rain pool on Long Key, and were taken during 1948 from several other Keys extending from Big Pine to Key Largo (*306*). The Long Key pool, which was said to be typical of the larval habitats, was in a shallow depression in the limestone located at the edge of a buttonwood transition zone between a hardwood forest and a black mangrove swamp. It was filled with a thick mat of purslane sesuvium (*Sesuvium portulacastrum*), but free of permanent aquatic vegetation. Various kinds of plants and trees surrounding the pool formed dense shade. These larvae were associated with a dozen other species of both fresh and salt-water mosquitoes. On Big Pine Key, one of the breeding places was a pool about 12 feet in diameter and 3 feet deep filled with clear fresh water and only partially shaded. The bottom of the pool was covered with water hissop (*Bacopa monnieri*). Another breeding site was a stagnant, sunlit pothole containing decaying vegetation. Among the larvae associated with *johnstonii* on this Key were those of *Anopheles albimanus* and *A. crucians.* Apparently the breeding pools on all the Keys contained only fresh rainwater.

In April 1948, after an exceptional amount of rainfall, females of *johnstonii* became very numerous and annoying (*306*). Biting counts of 100 per minute were obtained on two occasions, one at 11 a.m. and one at 2 p.m. They were said to bite at any time during the day, either in shade or bright sunlight and were very aggressive. This species was previously known only from the Greater Antilles.

ADULT.—Proboscis and palpi dark. Occiput with rather broad, recumbent whitish scales. Mesonotum covered with fairly broad yellowish white scales extending over prescutellar space and the scutellum. Wing length about 3.5 mm., the scales dark. Legs and abdomen blue-black, small femoral knee spots present; tarsi all dark except segment 4 of the hind feet which is usually white dorsally on the basal four-fifths (sometimes all dark). Segment 1 of the abdomen with wide white band, the other tergites with large apical, lateral white spots that extend onto the dorsum.

LARVA.—Antenna about as long as head, with a multiple tuft beyond the middle of shaft. Upper head hair double, the lower, double or triple, both short. Lateral abdominal hairs multiple on segments 4 to 6. Comb of about six thorn-shaped scales, on a weakly sclerotized plate, the lateral spinules fairly stout. Air tube stout, inflated, about 3:1, the tuft minute, multiple, inserted beyond middle; hair on lateral valve nearly as long as the apical diameter of tube; pecten usually with 6 to 8 spines, each with two or three teeth on one or both sides at base. Anal segment completely ringed and pierced by tufts of the ventral brush, the lateral hair very small, multiple, branched from base. Gills pointed, about 1.5 times as long as the segment.

PSOROPHORA LONGIPALPIS Roth

This mosquito was described as new by Roth in 1945 (*273*). It had previously been confused with *Psorophora horrida,* which it

closely resembles. The holotype male was from Fayetteville, Ark., and the paratypes from Kansas, Missouri, Oklahoma, South Dakota, and Texas. Wirth (*332*) identified larvae and reared adults of this species collected in 1943 at Rapides, near Alexandria, La. No information was given as to their breeding or biting habits, but these presumably are similar to those of *P. horrida*.

ADULT.—Proboscis and palpi dark, the latter more than a third as long as the proboscis. Occiput with a large median area of broadened, recumbent pale scales, a patch of broad, appressed, violaceous scales on each side. Mesonotum with a wide median dark stripe, bordered by wide stripes of broad yellowish-white scales covering the lateral surfaces, and with whitish scales around the prescutellar space and on the lobes of the scutellum. Wing about 4 mm., the scales dark. Legs and abdomen blue-black. Femoral knee spots absent, tibiae and tarsi all dark except the last two segments of the hind feet which are all white. First segment of abdomen with an apical white band, the other tergites with small lateral apical spots, scarcely visible from above.

LARVA.—Antenna somewhat longer than the head, the tuft multiple. Upper and lower head hairs moderately long, double. Lateral abdominal hairs multiple on segments 4 to 6. Comb usually with seven thorn-shaped scales in a curved row. Air tube inflated, about 3.5:1, the tuft minute inserted high on side of tube at about the apical third; pecten of only 3 or 4 spines, each with a stout tooth at base. Anal segment completely ringed and pierced by tufts of the ventral brush, the lateral hair small, branched toward tip. Gills about 1.5 times the length of the segment.

PSOROPHORA PYGMAEA (Theob.)

A small tropical *Grabhamia* with a wide white ring on the proboscis, but with the tarsal rings narrow and confined to the base of the segments. It was first collected at Key West, Fla., in 1901 (A. Busck, four specimens) and in 1903 (E. A. Schwartz, six specimens). These were described as *Culex nanus* by Coquillet (*80*), but this name was placed as a synonym of *Psorophora pygmaea* by Howard, Dyar, and Knab (*163*). The type locality of *pygmaea* was Antigua. Buren (*61*) reported that 37 specimens, all females, were taken in a light trap at the U. S. Quarantine Station on Fisher's Island, Miami Beach, Fla., in June and July 1946. No breeding could be found on Fisher's Island or Miami Beach. The author believed, therefore, that it must have occurred on Virginia or Biscayne Keys. He also reported that the U. S. National Museum has 30 specimens collected at Key West from June to October 1924, a previously unpublished record. More recently *pygmaea* has been collected in light traps in St. Lucie, Martin, and Palm Beach Counties (*53*). The species has been recorded from the Bahamas and the Greater Antilles.

ADULT.—Proboscis with a broad central white ring, the palpi speckled with white, Mesonotum with narrow golden or brownish scales. Wing length about 3 mm., the scales broadened, speckled with white, but without white spots. Femora and tibiae sprinkled with white, the femora with narrow subapical white rings, sometimes indistinct, tarsal segments with narrow basal white rings. Abdominal segments with wide apical white bands produced forward in middle.

LARVA.—Antenna of normal size, with a multiple tuft inserted before the middle. Upper and lower head hairs long, single, subequal. Comb, a curved row of about six stout scales, each rounded, with a long apical spine twice as long as the longest side spines, the comb set on a weak plate. Air tube 3:1, somewhat inflated, with a small multiple tuft near middle; pecten of about six spines, each with several stout teeth on one side toward the base; hair on lateral valve of tube minute, less than half as long as apical diameter of tube. Anal segment with the plate pierced by tufts of the ventral brush. Gills about one and one-half times as long as the segment, pointed.

PSOROPHORA SIGNIPENNIS (Coq.)

This species of *Grabhamia* resembles *P. discolor* in having white spots on the wing, but it also has pale fringe spots opposite the tips of the veins, which are not present in that species. It occurs principally in the plains and valleys west of the Mississippi River. It is adapted to arid conditions and development of the larvae in transient pools and irrigated fields is very rapid. The females attack man but, in Oklahoma, were rarely observed biting in spite of an abundance of larvae and of adults in light traps (*275*). *P. signipennis* is rare in the Southeast and has been reported only from Arkansas (*96, 54*) and Tennessee (*222*). Its range extends from North Dakota to Texas and westward to Arizona and Mexico.

ADULT.—Proboscis with a very broad median white ring. Palpi speckled with white. Mesonotum with pale brownish scales, paler around sides and posteriorly. Wing about 3.5 mm. in length, with mixed black and white scales and several distinct white spots, two on the apical half of the costa, separated by a slightly longer black spot, one at the tip of the anal vein and a long one covering most of the basal half of this vein; pale fringe spots present opposite the tips of all the longitudinal veins. Femora and tibiae speckled with white, the femora with narrow, preapical, pale rings; tarsal segments with basal white rings, and segment 1 with a median white area covering about two-thirds of the segment on the hind foot, the ring on segment 2 of the hind foot more than half as long as the segment. Abdomen largely pale-scaled, speckled, and streaked with dark.

LARVA.—Antenna shorter than head, with a large multiple tuft inserted about the middle of the shaft, the branches conspicuously feathered. Preantennal tuft with six or seven branches. Upper and lower head hairs long, usually single, sub-equal in length, sometimes one or more, rarely all four, branched (*147*). Comb, a curved row, usually of six scales set on a small plate, each scale with a long central spine and a few short lateral spinules. Air tube about 3.5:1, somewhat inflated, with a very small multiple tuft near the apical third; hairs on the lateral valves nearly as long as the apical diameter of the tube; pecten of about six spines. Anal segment ringed by the plate, which is penetrated by tufts of the ventral brush. Gills all of equal length, about twice as long as the segment.

PSOROPHORA VARIPES (Coq.)

This widely distributed *Janthinosoma* has a broad median dark stripe on the thorax (fig. 19, *G*) and a white band on segment 4 only of the hind tarsus. The larvae occur in temporary woodland pools and are frequently associated with *P. ferox*. In Louisiana, Buren (*60*) found them breeding abundantly in woodland floodwaters and nearly absent in temporary rain pools. The larvae were collected in mats of debris. This species is comparatively rare in most of the Southeast but the writers found it to be exceedingly annoying in the woods of northeastern Louisiana. It did not fly out in the sunlight to bite. In Arkansas it was said to be normally an inhabitant of the woods along large streams and rivers, and was present in swarms as soon as the water had partly receded (*156, 157*). In southern Mississippi, on one occasion in 1943 the females occurred in almost unbearable swarms in wooded swamps along the Leaf River (*225*). *P. varipes* has previously been reported from all the Southeastern States (*193*). It also occurs in many of the States from New York to Missouri and Texas, and its range extends into Mexico, Central, and South America.

ADULT.—Proboscis and palpi dark. Mesonotum with a very broad median stripe of brown lanceolate scales and narrower lateral stripes of broad

yellowish-white scales, with similar broad scales around the prescutellar space and on the lobes of the scutellum. Wing length about 3.5 mm., the scales all dark. Legs and abdomen blue-black with violet reflections. Knee spots absent. Tibiae and tarsi all dark except segment 4 of hind foot which is pale-scaled dorsally. Segment 1 of abdomen with an apical triangular white patch, the other tergites with lateral, apical white spots, visible from above.

LARVA.—Antenna slightly longer than the head, with a multiple tuft near or beyond the middle. Upper and lower head hairs both long, two- to four-branched, the upper usually double, the lower double or triple. Lateral abdominal hairs four- or five-branched on segment 3, single or double on segments 4 to 6. Comb with six or seven scales in a strongly curved row, the single scale thornlike with fairly strong lateral spinules. Air tube inflated, about 3.5:1, a small multiple tuft beyond middle of tube; pecten of three or four spines. Anal segment with the plate pierced by tufts of the ventral brush. Gills about 1.5 times as long as the segment.

Genus TOXORHYNCHITES Theobald

(Syn., *Megarhinus* Rob.-Desv.)

The subfamily Toxorhynchitinae has a single genus, and is represented in the United States by a single species with two subspecies, both of which are found in the Southeast. These were previously listed as full species but Jenkins (*173*), after a detailed study, considered them to be only of sub-specific rank. The genus has long been known as *Megarhinus* but this name was found to be preoccupied and could no longer be used under the rules of priority.

These are very large, brilliantly colored, non-bloodsucking mosquitoes. The long, tapered proboscis, the basal half of which is rigid, has the apical half bent downward at nearly a right angle (fig. 2, *A*), and not fitted for puncturing. The female palpi are about two-thirds as long as the proboscis, the clypeus is longer than broad, the male antenna plumose, the scutellum evenly rounded as in *Anopheles*. The second marginal cell of the wing is much shorter than its petiole. The wing spread is about 15 mm. The two subspecies are indistinguishable except for the slight differences in the white markings of the male tarsi.

Breeding occurs chiefly in tree holes, and occasionally in rock holes and artificial water containers. The larva is very large, a strong swimmer, and is predaceous on other mosquitoes, or sometimes cannibalistic. The head is nearly square and the mouth brushes each consist of about 10 strong, curved rods. These were previously thought to be adapted for grasping their prey but Breland (*56*, *57*), in studies of *Toxorhynchites rutilus septentrionalis* in Central Texas, noted that only the mandibles were used for capturing the prey, and he concluded that the mouth brushes were not employed for this purpose. The eighth segment of the larva has a sclerotized plate bearing two stout barbed hairs and two minute branched hairs on the posterior margin. The usual comb and pecten are lacking.

KEY TO SUBSPECIES

MALES

1. Segment 2 and part of segment 3 of front tarsus, and usually segment 5 of hind tarsus white. Florida, Georgia, and South Carolina ..... *rutilus rutilus*

   Front tarsus and usually the fifth hind tarsal entirely dark. Occurs sparingly in most of the South ..... *rutilus septentrionalis*

TOXORHYNCHITES RUTILUS RUTILUS (Coq.)

A very large irridescent mosquito, the larvae of which are found in tree holes and artificial water containers. They were collected in Florida in "surprising numbers" in the native bromeliad *Tillandsia utriculata* L., with larvae of *Wyeomyia vanduzeei* and *mitchellii* (*284*). The authors found none of the larvae in innumerable tree holes examined in the same areas. However, other workers have collected them in a wide variety of places in various parts of Florida, including holes in water oak, live oak, scrub oak, orange, pecan, and pine trees, and from glass jars, tin cans, wooden barrels, an auto tire, steel drum, a rowboat, and others (*19*). These authors reported that one larva collected in the first instar devoured 118 *Orthopodomyia signifera* and *Aedes triseriatus* larvae, pupated in 16 days, and emerged in 4 more days. Another larva collected in the third instar devoured 112 larvae, pupated in 22 days, and emerged in 5. The larval period has been observed by others to last as long as six months. The larvae are fairly active but often hang quietly below the surface of the water at various angles or rest on the bottom or sides of the container. They attack each other if other food is not available. The adults are mainly crepuscular and were observed flying in the woods from about 5 p.m. until dark (*174*). A female was observed dipping up and down over water in a tree hole as if ovipositing, but no eggs were found. It is presumed that the adults feed on flower nectar as do other members of the genus.

This subspecies was previously listed from Florida and Georgia (*193*). Since then it has been recorded from numerous additional places in Florida (*284, 174, 19, 173*), from Thomas County, Georgia (*174*) and Myrtle Beach, S. C. (*67*). Of 10 males reared in the last locality, 3 were *rutilis* and the others *septentrionalis*. There are a few records from other localities based on females only, but these cannot be relied upon in areas where the two subspecies may overlap.

ADULT.—Proboscis and palpi as described under the genus. Occiput covered with broad flat irridescent bluish scales. Mesonotum with a narrow median stripe, tapered posteriorly, and lateral borders of white or golden-yellowish scales, the rest of the scutum with fine dark scales. Wing about 6 mm., the scales sparse and fairly broad; second marginal cell less than half as long as its petiole. Front and mid tarsi of female with the second, third, and most of the fourth segments white, the hind tarsi with the fourth and most of the fifth segments white. Male with the second and basal two-thirds of the third segments of the fore and mid tarsi white dorsally, the hind tarsi usually with the fifth segment all white. Abdomen dark blue above, yellowish below.

LARVA.—Antenna very small, with a pair of single hairs and a minute, multiple tuft toward the apex. Mouth brushes each consisting of about 10 strong, curved rods apparently adapted for grasping prey, but as previously mentioned in the discussion of the genus, Breland (*57*) has cast doubt on this assumption. Upper and lower head hairs and preantennal hair each single, small. Eighth abdominal segment with a large sclerotized plate bearing two stout spinulose hairs and two minute tufts on its posterior border. Air tube small, about 2:1, pecten lacking, a large hair tuft near the basal fourth. Anal segment ringed by plate with a stout spinulose lateral hair, Gills very short, bulbous.

TOXORHYNCHITES RUTILUS SEPTENTRIONALIS (D. and K.)

This subspecies breeds in situations very similar to those of the

preceding subspecies except that it has not been taken from bromeliads; in fact, has not as yet been reported as far south as the northern limits of these native air plants. Breland (*56, 57*), who has made a study of this mosquito in Texas, reports that the eggs are oval in shape, pure white in color, and studded with small tubercles. Females were observed dipping over the water surface and it was thought that this was the method of oviposition. Larvae fed on other mosquito larvae, reached the 4th instar rapidly, but remained in this stage without pupation for several months unless adult fruit flies (*Drosophila*) were added to the diet. On a pure diet of fruit flies, or when these were added during the late instars, the cycle from egg to adult was completed in 25 to 35 days. Other workers, however, have reared larvae to the adult stage without supplying them with adult flies. In watching the feeding of the larvae under a binocular microscope, Breland found that they seized their prey with the mandibles only, and that the modified mouth brushes were not used at all for this purpose. Apparently no actual use of the mouth brushes for grasping has been observed by others.

The larvae are usually associated with *Orthopodomyia signifera* and *alba*, *Aedes triseriatus*, and *Anopheles barberi*, which presumably serve as food. The species is said to pass the winter in the larval stage, but Breland thought that in central Texas they probably overwinter as adults.

The adults have been observed visiting flowers, and it is thought that flower nectar is their principal source of nourishment. They usually remain in the woods and are active during the day and early evening. In Arkansas, the males were observed to congregate regularly at a particular tree or bush (*303*). The resting places of females were not observed.

The range of this mosquito extends from New Jersey to Florida and westward to eastern Texas, Oklahoma, and Kansas. It was previously listed from all the Southeastern States except Florida (*190*). Since then, records have been added from Jacksonville (*232, 19*), and Tallahassee, Fla. (*19*). It therefore overlaps the range of *r. rutilis* in northern Florida, southern and eastern Georgia, and eastern South Carolina.

ADULT.—This subspecies appears to be indistinguishable from the previous one in all characteristics except the white scaling on the male tarsi, as given in the Key. In typical male specimens, the front tarsus is all dark, the mid tarsus with segment 2 white on one side or dark, the hind tarsus with segment 4 white, and segment 5 usually dark. Various intergrades in coloration occur in the region where the two overlap (*173*), and with atypical specimens, identification may be difficult or impossible.

LARVA.—Description the same as for subspecies *rutilus*.

Genus URANOTAENIA Lynch-Arribalzaga

The species of this genus are small and sometimes brilliantly colored. They are recognized by the very short forks of wing vein 2, and short palpi in both sexes. The male antennae are plumose. One spiracular bristle is present, post-spiracular bristles are lacking, the postnotum and the squamae are bare. The anal vein is short, ending before the level of the fork of vein 5. In the larva, the head is longer than broad and dark colored. The upper and lower head hairs in our local species are single, stout, and spine-

like (fig. 16, *A*). The eighth abdominal segment has a lateral plate, the comb scales forming a row on the posterior border. The air tube has a pecten and a single pair of ventral brushes. The anal segment is ringed by the plate.

KEY TO SPECIES

ADULTS

1. Mesonotum with a narrow median longitudinal line of bright bluish scales (fig. 19, *J*); tarsi all dark. A common species .. *sapphirina*
   Mesonotum dark-scaled above, with a short line of purplish scales on lateral margin; apex of third and entire fourth and fifth hind tarsal segments white. Common in Florida and southern Louisiana ..... *lowii*

LARVAE (FOURTH INSTAR)

1. Upper lateral hair of abdominal segments 1 and 2 triple .... *sapphirina*
   Upper lateral hair of segments 1 and 2 double (lower hair single in both species) ..... *lowii*

URANOTAENIA LOWII Theob.

(Syn., *U. continentalis* D. and K.)

The larvae occur in ground pools, especially in the grassy margins of ponds and lakes. Their breeding habits are similar to those of *U. sapphirina*. In New Orleans, La., the larvae were found in a pool densely filled with *Myriophyllum verticulatum* (*154*). The adults were not observed except in the vegetation of the pool or resting on the water. The females could not be induced to bite. From a study of the feeding habits of this mosquito in Louisiana, Remington (*263*) reported that they fed readily in cages on several kinds of amphibians including frogs (*Rana* and *Hyla*), toads (*Bufo*), and a salamander (*Desmognathus*). They were not interested in a tortoise (*Terrapene*), two kinds of lizards (*Leiolopisma* and *Anolis*), earthworms, snails, land slugs, or man. Females were observed biting on frogs in the field. The adults were commonly collected in light traps at Camp Shelby, Miss. (*225*), and in Florida (*50*).

The species was previously reported from all the Southeastern States except Tennessee and North Carolina (*193*), and a record from North Carolina has since been added (*228*). In southern Florida it is the more prevalent of the two species of *Uranotaenia* and was said to be common on the Keys (*252*). It occurs also in Texas, and its range includes Mexico, the Caribbean region, and South America.

ADULT.—Proboscis and palpi dark. Occiput covered with broad appressed scales, the median area dark, but with purplish scales laterally and around eye margin. Mesonotum all dark-scaled above, with a short line of purple scales on the lateral margin. There are patches of pale purplish scales on the sides of the thorax and on the pronotal lobes. Wing length about 2.5 mm. or less, scales rather sparse and broadened, a short line of purplish scales at the bases of veins 1 and 5. Legs with small white spots at the tips of the femora and tibiae, the hind tarsi with the fourth and fifth segments and apex of third white, the fore and mid tarsi all dark. Abdomen dark above, some of the segments with lateral apical spots of purplish scales.

LARVA.—Antenna very short, with a small single hair at about the basal third. Upper and lower head hairs stout, single, spinulous. Upper lateral hair of abdominal segments 1 and 2 double, the lower single. Segment 8

with a large sclerotized plate and about eight comb scales on the posterior border, each scale long, pointed, and finely fringed on each side nearly to tip. Air tube about 4:1, with one pair of large multiple tufts attached near the middle, the pecten teeth rounded, and finely fringed from base to apex. Anal segment longer than wide, ringed by plate. Gills shorter than segment, bluntly rounded.

URANOTAENIA SAPPHIRINA (O.-S.)

(Syn., *U. socialis* Theob.)

A small species, slightly larger than *U. lowii*, with a median line of brilliant blue scales on the thorax. It breeds in permanent grassy pools, swamps, and vegetation at the margin of lakes. It is often found in growths of *Lemna*, and is a frequent associate of *Anopheles quadrimaculatus* and *Culex erraticus*. In Tennessee, it was found more often with *Anopheles punctipennis* and *Culex apicalis* (= *C. territans*) (*290*). Thibault (*303*) said it was one of the most abundant mosquitoes in Lonoke and Pulaski Counties, Arkansas, though the adults were not generally in evidence. They have, however, been observed in considerable numbers during the winter months in caves and hollow trees, and on one occasion in enormous numbers in December in old Fort Jackson below New Orleans (*154*). Since few larvae could be found nearby, it appeared that they must have come from some distance away. That they are capable of flying considerable distances is shown by the capture of adults in light traps in Delaware Bay where the nearest shore was about 8 miles away (*209*). In southern Mississippi they were reported to pass the winter in large hollow trees (*225*). There are apparently no definite records of their biting persons, and their feeding habits are unknown. It is doubtful that the females attack any warm-blooded animals.

The species is a common one throughout the Eastern and Central States, and has been recorded from all the Southeastern States (*193*). It occurs also in southeastern Canada, Mexico, and parts of the West Indies.

ADULT.—Proboscis and palpi dark. Occiput with a border of broad purplish scales around the eyes. Mesonotum with a narrow median longitudinal line of broad, brilliant blue scales extending on to the mid lobe of the scutellum, and lateral lines of similar scales in front of the wing base, the rest of the scutum with fine dark scales; patches of bluish scales also present on the pleurae and pronotal lobes. Wing length about 2.5 mm. or more, with a line of purplish scales on the basal part of vein 5 and a few similar scales at the base of vein 1. First marginal cell less than half as long as its petiole. Tarsi all dark, the tips of the femora and tibiae with small white spots. Third, fifth, and sometimes the sixth abdominal tergites with a narrow apical white band widened in the middle, or a rounded median patch.

LARVA.—Very similar to the preceeding species. Antenna with a small single hair at about the basal third. Upper and lower head hairs very stout, tapered, spinelike. Upper lateral hair of abdominal segments 1 and 2 triple (instead of double as in *U. lowii*), the lower hair single. Comb of about eight scales set on the posterior edge of a large sclerotized plate, each scale pointed and finely fringed on about the basal half. Air tube about 4:1, with a pair of multiple tufts near the middle, the pecten teeth rounded and nearly completely fringed. Gills slightly shorter than the anal segment, pointed.

Genus WYEOMYIA Theobald

The species of this genus are very small, and are distinguished from other genera by the presence of a tuft of setae on the post-

notum. The most obvious recognition characters are the vestiture of broad dark scales on the thorax and the markings of the abdomen, which is usually somewhat compressed laterally, and on which the dark scaling of the dorsum and the white scaling of the venter meet to form a straight line along the sides. The male palpi are short; the antennae similar to those of the female. The mesonotum lacks the dorsocentral bristles and is covered with broad, appressed scales instead of the narrow, semi-erect scales of *Culex*. Spiracular and upper mesepimeral bristles are present, the postspiracular and lower mesepimeral bristles lacking. The first submarginal wing cell is as long as its petiole. The tarsi of all the local species have some white markings, but these may be indistinct and easily overlooked in dead specimens, or the extent of the pale scaling may appear different in different positions. The claws of both sexes are simple. The tip of the female abdomen is blunt, and segment 8 is not retractile. In the male the apical half of the dististyle is greatly enlarged and divided lengthwise into several lobes or arms.

In the larva the head is wider than long, the comb scales are in a single row, the air tube is without a pecten, and has scattered single or double hairs. The anal segment is without a ventral brush, but has a pair of ventrolateral tufts (fig. 15, *C*) ; the plate covers only about half the segment.

KEY TO SPECIES

ADULTS

1. Scales of anterior pronotal lobe silvery white ..... *vanduzeei*
   Scales of anterior pronotal lobe darker, violaceous, sometimes whitish at sides (female of all species difficult to distinguish) .. 2
2. Scutellar scales all of same coppery color ..... *mitchellii*
   Scutellum with a small patch of pale scales on mid lobe ..... *haynei*

MALE TERMINALIA

1. Stem of dististyle slender, longer than the modified head section ..... *mitchellii*
   Stem of dististyle stout, shorter than the head section 2
2. Head section of dististyle divided into two lobes and a curved arm, the middle lobe without a group of setae ..... *haynei*
   Head section of dististyle divided into three lobes and a straight, slender arm, the mid lobe with a group of about 10 long setae about the middle of the outer border ..... *vanduzeei*

LARVAE (FOURTH INSTAR)

1. Upper head hairs multiple, the lower double; ventrolateral tufts of anal segment of about 12 subequal hairs ..... *mitchellii*
   Upper and lower head hairs single; ventrolateral tufts of anal segment with not over six hairs 2
2. Ventrolateral tufts of anal segment with two long hairs; gills with one pair much shorter than the other ..... *haynei*
   Ventrolateral tufts with one or two long hairs and three or four much shorter ones; gills very long and equal in length .... *vanduzeei*

WYEOMYIA HAYNEI Dodge

(Syn., *W. smithii* (southern records, not Coquillett))

Records of the northern pitcherplant mosquito *Wyeomyia smithii*

from North and South Carolina and Alabama are probably of this species. *W. haynei* was described by Dodge (*89*) as a distinct species, the larvae of which were collected from the southern subspecies of the pitcherplant *Sarracenia purpurea venosa* Raf. The two species are very similar in nearly all characters. The author identified specimens from Theodore, Ala., and several localities in North and South Carolina. The type locality for *haynei* is near Columbia, S. C. The species has also been reported from a few other localities in South Carolina (*321*). The collection in the U. S. National Museum includes specimens from four localities in North Carolina. It is recorded also from Escambia County, Florida (*53*).

ADULT.—Proboscis long, all dark; palpi very short in both sexes. Occiput with broad flat scales, mostly dark with metallic reflections, a small patch of white at vertex. Mesonotum with broad, dark, appressed scales. Scutellum with a patch of silvery scales on the mid lobe, the rest dark. Anterior pronotal lobe large, covered with broad, bluish or violaceous scales, the posterior pronotum and pleurae with patches of silvery-white scales. Wing length about 2.5 mm., the scales narrow and dark. Fore tarsus dark, mid tarsus described as having segments 3 and 4, and the tip of 2, white on one side (dorsally), the hind tarsus pale-striped underneath throughout, or the apical segments darker (these markings found to be indistinct or indefinite on mounted specimens); femoral knee spots absent. Abdomen laterally compressed, the tergites all dark, the sternites all white. The apical half of the male dististyle has an elongate mid lobe, a slender, curved, spinose arm arising from its base, and a quadrate lateral lobe; the basal half stout, about as long as the apical mid lobe.

LARVA.—Antenna short, with a single hair inserted at about the distal third. Upper and lower head hairs and preantennal hair each single, about as long as antenna. Lateral abdominal hair usually double or triple on segments 3 to 6. Comb scales in a single row, each rounded and finely fringed to tip. Air tube about 4:1, with numerous long, usually single, scattered hairs, the pecten lacking. Anal segment ringed about halfway with the plate, the lateral and dorsal hairs very long, double; the ventrolateral hair much shorter, also double. Gills with one pair longer than the segment, swollen, and rounded; the dorsal pair much shorter, bulbous.

WYEOMYIA MITCHELLII (Theob.)

A small forest mosquito with white bands on some of the tarsal segments. The larvae are found only in water that collects at the base of the leaves of epiphytic Bromeliaceae (pl. 10). They occur throughout the year except when the breeding places become dry. The females bite readily during the daytime and sometimes cause considerable annoyance in shady, humid woodlands or yards with trees in which the bromeliads grow. They do not fly far from their breeding sites. On one occasion the writers observed an annoying infestation in a greenhouse where the larvae were found in a large collection of exotic bromeliads. The white markings on the feet are more noticeable when the insects are alive, either flying or at rest, when the hind legs are turned up over the back with the tarsi pointing forward. The species is found in the United States only in the southern half of Florida. Specimens have been taken as far north as Orange and Volusia Counties (latitude about 29°). They occur in the West Indies.

ADULT.—Proboscis long, dark, the palpi very short. Occiput with a line of white scales around eye margin and a white patch at vertex. Mesonotum and scutellum with broad, appressed dark scales. Anterior pronotal lobes covered with dark bluish or violaceous scales, sometimes with paler scales around the edges; posterior pronotal lobes and pleurae with patches of silvery white scales. Wing length about 2.5 mm., the plume scales narrow and dark. Femoral knee spots absent. Fore tarsi all dark; mid tarsi white streaked on

one side on segments 3 and 4, the tip of 2 and sometimes 5; hind tarsi with white basal spots or lines underneath on segments 1 to 3, sometimes also on 4 and 5. Female abdomen somewhat compressed laterally, the tergites all dark, and the sternites all white, as in other members of the genus. Head of male dististyle greatly enlarged with a broad quadrate mid lobe having a thumblike projection on one side, an ovate lobe from the base on one side, and a straight slender arm on the other; stem of dististyle slender, longer than the head.

LARVA.—Antennal hair small, three-branched, inserted at about the distal third of the shaft. Lower head hair long, double, the upper and preantennal hairs three- or four-branched. Lateral abdominal hairs usually double on segments 3 to 6. Comb of numerous scales in a long row, each pointed, and finely fringed nearly to the tip. Air tube about 4:1, with scattered long, single hairs and a few shorter double hairs toward the tip; the pecten lacking. Plate of anal segment covers about three-fourths of the surface; the lateral and dorsal hairs each very long, single; the ventrolateral hairs shorter than the segment, multiple, subequal in length. Gills somewhat longer than the segment, all of equal length and bluntly pointed.

WYEOMYIA VANDUZEEI D. and K.

The habits and distribution of this species are almost identical with those of *Wyeomyia mitchellii*. In Florida the larvae of the two species are usually found associated in the bromeliads (pl. 10) and the adults fly together in the woods.

ADULT.—Very similar to *W. mitchellii* except for slight differences in the color of the scales on the anterior pronotal lobe, which are silvery white in *vanduzeei* but darker, with purplish reflections, in *mitchellii*. The midlobe of the scutellum in both species lacks the spot of white scales found in *W. haynei*. The head section of the male dististyle is divided into three elongate lobes and a long slender arm, the mid lobe with about 10 long setae in a group on one side near the middle.

LARVA.—Differs from *W. mitchellii* in a number of respects, as follows: antennal, preantennal, and upper and lower head hairs each single; lateral abdominal hairs single on segments 3 to 6; comb scales rounded and finely fringed to tip; air tube 5:1 or 6:1, with a row of about six small, single or double hairs dorsally, one pair of double hairs laterally toward the base, and several small single ventrolateral hairs toward the tip. Lateral hair of anal segment double, about three-fourths as long as the dorsal hairs, the ventrolateral tuft with four to six hairs, three or four of which are short and one or two much longer. Gills about four times as long as the segment, broad, bluntly rounded.

LITERATURE CITED

(1) ABDEL-MALEK, ALBERT
1948. THE BIOLOGY OF AEDES TRIVITTATUS. Jour. Econ. Ent. 41: 951-954.

(2) AMERICAN MOSQUITO CONTROL ASSOCIATION.
1948. THE USE OF AIRCRAFT IN THE CONTROL OF MOSQUITOES. Amer. Mosquito Control Assoc. Bul. No. 1, 46 pp., illus.

(3) AMERICAN MOSQUITO CONTROL ASSOCIATION.
1952. GROUND EQUIPMENT AND INSECTICIDES FOR MOSQUITO CONTROL. Amer. Mosquito Control Assoc. Bul. No. 2, 116 pp., illus.

(4) ATCHLEY, FLOYD O.
1952. DENSITIES OF ANOPHELES, SPOROZOITE RATES IN ANOPHELES, AND INCIDENCE OF MALARIA IN AN AREA OF SOUTH CAROLINA. Amer. Jour. Trop. Med. and Hyg. 1: 743-746.

(5) BAKER, F. C.
1936. A NEW SPECIES OF ORTHOPODOMYIA, O. ALBA, SP. N. Proc. Ent. Soc. Wash. 38: 1-7, illus.

(6) BALFOUR, MARSHAL C.
1928. STUDIES ON THE BIONOMICS OF NORTH AMERICAN ANOPHELINES. WINTER ACTIVITIES OF ANOPHELINES IN COASTAL NORTH CAROLINA 36° N. LAT. Amer. Jour. Hyg. 8: 68-76, illus.

(7) BANG, F. B., QUINBY, G. E., and SIMPSON, T. W.
1940. ANOPHELES WALKERI (THEOBALD): A WILD-CAUGHT SPECIMEN HARBORING MALARIA PLASMODIA. U. S. Pub. Health Serv. Rpts. 55: 119-120, illus.

(8) ——— QUINBY, G. E., and SIMPSON, T. W.
1943. STUDIES ON ANOPHELES WALKERI THEOBALD CONDUCTED AT REELFOOT LAKE, TENNESSEE, 1935-1941. Amer. Jour. Trop. Med. 23: 247-273.

(9) BARBER, M. A.
1927. THE FOOD OF ANOPHELINE LARVAE—FOOD ORGANISMS IN PURE CULTURE. U. S. Pub. Health Serv. Rpts. 42: 1494-1510. illus.

(10) ———
1928. THE FOOD OF CULICINE LARVAE. U. S. Pub. Health Serv. Rpts. 43: 11-17.

(11) ——— and HAYNE, T. B.
1921. ARSENIC AS A LARVICIDE FOR ANOPHELINE LARVAE. U. S. Public Health Serv. Rpts. 36: 3027-3034.

(12) ——— and HAYNE, T. B.
1924. SOME OBSERVATIONS ON THE DISPERSAL OF ADULT ANOPHELES. U. S. Pub. Health Serv. Rpts. 39: 195-203.

(13) ——— and KOMP, W. H. W.
1929. BREEDING PLACES OF ANOPHELES IN THE YAZOO-MISSISSIPPI DELTA. U. S. Pub. Health Serv. Rpts. 44: 2457-2462.

(14) ——— KOMP, W. H. W., and HAYNE, T. B.
1924. SOME OBSERVATIONS ON THE WINTER ACTIVITIES OF ANOPHELES IN SOUTHERN UNITED STATES. U. S. Pub. Health Serv. Rpts. 39: 231-246.

(15) ——— KOMP, W. H. W., and HAYNE, T. B.
1927. THE SUSCEPTIBILITY TO MALARIA PARASITES AND THE RELATION TO THE TRANSMISSION OF MALARIA OF THE SPECIES OF ANOPHELES COMMON IN SOUTHERN UNITED STATES. U. S. Pub. Health Serv. Rpts. 42: 2487-2502.

(16) BARR, A. RALPH.
1957. THE DISTRIBUTION OF CULEX P. PIPIENS AND C. P. QUINQUEFASCIATUS IN NORTH AMERICA. Amer. Jour. Trop. Med. & Hyg. 6: 153-165.

(17) BARR, A. R., and KARTMAN, L.
1951. BIOMETRICAL NOTES ON THE HYBRIDIZATION OF CULEX PIPIENS L. AND C. QUINQUEFASCIATUS SAY. Jour. Parasitol. 37: 419-420.

(18) BASHAM, ERNESTINE H.
1948. CULEX (MELANOCONION) MULRENNANI, A NEW SPECIES FROM FLORIDA (DIPTERA, CULICIDAE). Ent. Soc. Amer. Ann. 41: 1-7.

(19) ——— MULRENNAN, J. A., and OBERMULLER, A. J.
1947. THE BIOLOGY AND DISTRIBUTION OF MEGARHINUS ROBINEAU-DESVOIDY IN FLORIDA. Mosquito News 7: 64-66.
(20) BATES, MARSTON
1949. THE NATURAL HISTORY OF MOSQUITOES. 379 pp. New York.
(21) BEADLE, LESLIE D.
1952. EASTERN EQUINE ENCEPHALITIS IN THE UNITED STATES. Mosquito News 12: 102-107.
(22) BELLAMY, R. EDWARD
1939. AN ANOPHELINE FROM INLAND GEORGIA RESEMBLING THE BRACKISH-WATER RACE OF ANOPHELES CRUCIANS. Jour. Parasitol. 25: 186.
(23) ———
1956. AN INVESTIGATION OF THE TAXONOMIC STATUS OF ANOPHELES PERPLEXANS LUDLOW, 1907. Ent. Soc. Amer. Ann. 49: 515-529, illus.
(24) BENNETT, BYRON L., BAKER, FRED C., and SELLARDS, ANDREW WATSON.
1939. SUSCEPTIBILITY OF THE MOSQUITO AEDES TRISERIATUS TO THE VIRUS OF YELLOW FEVER UNDER EXPERIMENTAL CONDITIONS. Ann. Trop. Med. and Parasitol. 33: 101-105.
(25) BERTHOLF, J. H.
1951. REPORT OF THE BROWARD COUNTY, FLORIDA, ANTI-MOSQUITO DISTRICT 1950. Fla. Anti-Mosquito Assoc. Rpt. 22nd Ann. Meeting, section 5, not paged.
(26) BICK, GEORGE H.
1946. COLLECTIONS OF MOSQUITOES ON PARRIS ISLAND DURING 1945. Jour. Econ. Ent. (Sci. Note) 39: 89-91.
(27) BIDLINGMAYER, W. L.
1950. SOME OBSERVATIONS OF THE BIOLOGY OF MANSONIA MOSQUITOES IN THE LEESBURG AREA. Fla. Anti-Mosquito Assoc. Rpt. 21st Ann. Meeting, pp. 64-68.
(28) ———
1954. DESCRIPTION OF A TRAP FOR MANSONIA LARVAE. Mosquito News 14: 55-58, illus.
(29) BISHOP, E. L.
1936. MALARIA-CONTROL ACTIVITIES OF THE TENNESSEE VALLEY AUTHORITY. U. S. Pub. Health Serv. Rpts. 51: 970-975.
(30) BISHOPP, F. C.
1933. MOSQUITOES KILL LIVE STOCK. Science 77: 115-116.
(31) BOHART, R. M.
1948. THE SUBGENUS NEOCULEX IN AMERICA NORTH OF MEXICO (DIPTERA, CULICIDAE). Ent. Soc. Amer. Ann. 41: 330-345.
(32) BOYD, MARK F.
1927. STUDIES ON THE BIONOMICS OF NORTH AMERICAN ANOPHELINES. I. THE NUMBER OF ANNUAL GENERATIONS OF A. QUADRIMACULATUS. Amer Jour. Hyg. 7: 264-275, illus.
(33) ———
1929. STUDIES ON THE BIONOMICS OF NORTH AMERICAN ANOPHELINES. PHYSICAL AND CHEMICAL FACTORS IN THEIR RELATION TO THE DISTRIBUTION OF LARVAE IN NORTHEASTERN NORTH CAROLINA. Amer. Jour. Hyg. 9: 346-370, illus.
(34) ———
1930. AN INTRODUCTION TO MALARIOLOGY. 437 pp., illus. Cambridge, Mass.
(35) ———
1930. STUDIES ON THE BIONOMICS OF NORTH AMERICAN ANOPHELINES. VI. SOME OBSERVATIONS ON IMAGINES. Amer. Jour. Hyg. 12: 449-466, illus.
(36) ——— editor.
1949. MALARIOLOGY. A COMPREHENSIVE SURVEY OF ALL ASPECTS OF THIS GROUP OF DISEASES FROM A GLOBAL STANDPOINT. Vols. I and II, 1643 pp., illus. Phila., and London.
(37) ——— and FOOT, HELEN.
1928. STUDIES ON THE BIONOMICS OF AMERICAN ANOPHELINES. THE ALIMENTATION OF ANOPHELINE LARVAE AND ITS RELATION TO THEIR DISTRIBUTION IN NATURE. Jour. Prev. Med. 2: 219-242, illus.

(38) ——— KITCHEN, S. F., and MULRENNAN, J. A.
1936. ON THE RELATIVE SUSCEPTIBILITY OF THE INLAND AND COASTAL VARIETIES OF A. CRUCIANS WIED. TO P. FALCIPARUM WELCH. Amer. Jour. Trop. Med. 16: 159-161.
(39) ——— and PONTON, GERALD.
1933. THE RECENT DISTRIBUTION OF MALARIA IN THE SOUTHEASTERN UNITED STATES. Amer. Jour. Trop. Med. 13: 143-166, illus.
(40) ——— and WEATHERSBEE, ALBERT A.
1929. STUDIES ON THE BIONOMICS OF NORTH AMERICAN ANOPHELINES. V. WINTER ACTIVITIES OF ANOPHELINE IMAGINES IN COASTAL NORTH CAROLINA (36° N. LAT.). Amer. Jour. Hyg. 9: 682-694, illus.
(41) BRADLEY, G. H.
1924. THE NATURAL BREEDING PLACES OF ANOPHELES MOSQUITOES IN THE VICINITY OF MOUND, LOUISIANA. Amer. Jour. Trop. Med. 4: 199-233, illus.
(42) ———
1925. THE LARVA OF AEDES THIBAULTI DYAR AND KNAB (DIPTERA, CULICIDAE). Insecutor Inscitiae Menstruus 13: 89-91.
(43) ———
1926. OBSERVATIONS ON THE EMERGENCE OF ANOPHELES MOSQUITOES. Amer. Jour. Trop. Med. 6: 283-297, illus.
(44) ———
1932. ON THE IDENTIFICATION OF ANOPHELES MOSQUITO LARVAE IN FLORIDA. Ent. Soc. Wash. Proc. 34: 41-43.
(45) ———
1932. SOME FACTORS ASSOCIATED WITH THE BREEDING OF ANOPHELES MOSQUITOES. Jour. Agr. Res. 44: 381-399, illus.
(46) ———
1936. ON THE OCCURRENCE OF ANOPHELES WALKERI THEOBALD IN FLORIDA (DIPTERA, CULICIDAE). South. Med. Jour. 29: 857-859, illus.
(47) ——— FRITZ, ROY F., and PERRY, L. E. .....
1944. ADDITIONAL MOSQUITO RECORDS FOR THE SOUTHEASTERN STATES. Jour. Econ. Ent. (Sci. Note) 37: 109.
(48) ——— GOODWIN, M. H. JR., and STONE, ALAN.
1949. ENTOMOLOGIC TECHNICS AS APPLIED TO ANOPHELINES. *In* Boyd, Malariology, I., pp. 331-378.
(49) ——— and KING, W. V.
1941. BIONOMICS AND ECOLOGY OF NEARCTIC ANOPHELES. *In* Human Malaria. Amer. Assoc. Adv. Sci. Pub. 15, pp. 79-87.
(50) ——— and MCNEEL, T. E.
1935. MOSQUITO COLLECTIONS IN FLORIDA WITH THE NEW JERSEY LIGHT TRAP. Jour. Econ. Ent. 28: 780-786.
(51) ——— and TRAVIS, BERNARD V.
1943. TIME-SAVING METHODS FOR HANDLING MOSQUITO LIGHT-TRAP COLLECTIONS. Jour. Econ. Ent. 36: 51-53.
(52) BRANCH, NINA
1955. NOTES ON THE IMPORTANCE OF CONTINUOUS ENTOMOLOGICAL RECORDS. Fla. Anti-Mosquito Assoc. Rpt. 26th Ann. Meeting, pp. 106-111.
(53) ——— LOGAN, LUCILLE, BECK, ELIZABETH, and MULRENNAN, J. A.
1958. NEW DISTRIBUTIONAL RECORDS FOR FLORIDA MOSQUITOES. Fla. Ent. 41:155-163.
(54) BRANDENBURG, J. F., and MURRILL, R. D.
1947. OCCURRENCE AND DISTRIBUTION OF MOSQUITOES IN ARKANSAS. Ark. Health Bul. 4: 4-6.
(55) BRELAND, O. P.
1947. VARIATIONS IN THE LARVAE OF THE MOSQUITO ORTHOPODOMYIA ALBA BAKER (DIPTERA, CULICIDAE). Brooklyn Ent. Soc. Bul. 42: 81-86.
(56) ———
1948. NOTES ON SOME CARNIVOROUS MOSQUITO LARVAE. Ent. News 59: 156-157.
(57) ———
1949. THE BIOLOGY AND THE IMMATURE STAGES OF THE MOSQUITO, MEGARHINUS SEPTENTRIONALIS DYAR AND KNAB. Ent. Soc. Amer. Ann. 42: 38-47, illus.

(58) BULL, CARROLL G., and REYNOLDS, BRUCE D.
1924. PREFERENTIAL FEEDING EXPERIMENTS WITH ANOPHELINE MOSQUITOES. II. Amer. Jour. Hyg. 4: 109-118, illus.

(59) ——— and ROOT, FRANCIS M.
1923. PREFERENTIAL FEEDING EXPERIMENTS WITH ANOPHELINE MOSQUITOES. I. Amer. Jour. Hyg. 3: 514-520, illus.

(60) BUREN, WILLIAM F.
1946. SOME OBSERVATIONS ON THE LARVAL HABITAT OF PSOROPHORA VARIPES (COQ.) (DIPTERA: CULICIDAE). Mosquito News 6: 120-121.

(61) ———
1946. PSOROPHORA PYGMAEA (THEOBALD), AN EXOTIC MOSQUITO NOW ESTABLISHED IN FLORIDA. Mosquito News 6: 185.

(62) ———
1947. A NEW AEDES FROM THE FLORIDA KEYS (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 49: 228-229.

(63) BURROUGHS, A. L., and BURROUGHS, R. N.
1954. A STUDY OF THE ECOLOGY OF WESTERN EQUINE ENCEPHALOMYELITIS VIRUS IN THE UPPER MISSISSIPPI RIVER VALLEY. Amer. Jour. Hyg. 60: 27-36.

(64) CARPENTER, STANLEY J.
1945. ARTIFICIAL SHELTERS FOR MEASURING DENSITIES OF ANOPHELES QUADRIMACULATUS. Jour. Econ. Ent. (Sci. Note) 38: 721-722.

(65) ———
1950. NOTES ON MOSQUITOES IN NORTH AMERICA: I—NEW DISTRIBUTION RECORDS FOR EASTERN UNITED STATES DURING 1946 AND 1947. Mosquito News 10: 64-65.

(66) ——— CHAMBERLAIN, ROY W., and WANAMAKER, JOHN F.
1945. NEW DISTRIBUTION RECORDS FOR THE MOSQUITOES OF THE SOUTHEASTERN STATES IN 1944. Jour. Econ. Ent. (Sci. Note) 38: 401-402.

(67) ——— and JENKINS, DALE W.
1945. A NEW STATE RECORD OF MEGARHINUS RUTILUS COQUILLETT IN SOUTH CAROLINA. Mosquito News 5: 88.

(68) ——— and LACASSE, WALTER J.
1955. MOSQUITOES OF NORTH AMERICA (NORTH OF MEXICO). 360 pp., illus. Univ. of Calif. Press, Berkeley and Los Angeles.

(69) ——— MIDDLEKAUFF, WOODROW W., and CHAMBERLAIN, ROY W.
1946. THE MOSQUITOES OF THE SOUTHERN UNITED STATES EAST OF OKLAHOMA AND TEXAS. Amer. Midland Nat. Monog. No. 3, 292 pp., illus. The Univ. Press, Notre Dame, Ind.

(70) CHAMBERLAIN, ROY W., and DUFFEY, THOMAS E.
1945. COLLECTION RECORDS OF MANSONIA TITILLANS (WALKER) AND MANSONIA INDUBITANS DYAR AND SHANNON IN FLORIDA WITH KEYS TO THE SPECIES OF MANSONIA IN THE UNITED STATES (DIPTERA, CULICIDAE). Mosquito News 5: 96-97.

(71) ——— RUBIN, HARRY, KISSLING, R. E., and EIDSON, M. E.
1951. RECOVERY OF THE VIRUS OF EASTERN EQUINE ENCEPHALOMYELITIS FROM A MOSQUITO, CULISETA MELANURA (COQUILLETT). Soc. Expt. Biol. and Med. Proc. 77: 396-397.

(72) ——— SIKES, R. K., NELSON, D. B., and SUDIA, W. D.
1954. STUDIES ON THE NORTH AMERICAN ARTHROPOD-BORNE ENCEPHALITIDES. VI. QUANTITATIVE DETERMINATIONS OF VIRUS-VECTOR RELATIONSHIPS. Amer. Jour. Hyg. 60: 278-285.

(73) ——— SUDIA, W. D., and NELSON, D. B.
1955. LABORATORY OBSERVATIONS ON A MOSQUITO, CULISETA MELANURA (COQUILLETT). Mosquito News 15: 18-21.

(74) CHAMBERLIN, JOSEPH C., and LAWSON, F. R.
1945. A MECHANICAL TRAP FOR THE SAMPLING OF AERIAL INSECT POPULATIONS. Mosquito News 5: 4-7, illus.

(75) CHAPMAN, H. C., and FERRIGNO, F.
1956. A THREE-YEAR STUDY OF MOSQUITO BREEDING IN NATURAL AND IMPOUNDED SALT-MARSH AREAS IN NEW JERSEY. N. J. Mosquito Extermin. Assoc. Proc. 43: 48-60.

(76) CHRISTOPHER, S. R.
1951. NOTE ON MORPHOLOGICAL CHARACTERS DIFFERENTIATING CULEX PIPIENS L. FROM CULEX MOLESTUS FORSKAL AND THE STATUS OF THESE FORMS. *In* Mattingly et al., The *Culex pipiens* Complex. Royal Ent. Soc., London, Trans. 102 (7): 372-379.

(77) CLARKE, J. LYELL
1943. STUDIES OF THE FLIGHT RANGE OF MOSQUITOES. Jour. Econ. Ent. 36: 121-122.

(78) COAD, B. R.
1913. OVIPOSITION HABITS OF CULEX ABOMINATOR DYAR AND KNAB. Can. Ent. 45: 265-266.

(79) COOK, S. S., and WILLIAMS, L. L., JR.
1928. AIRPLANES AND PARIS GREEN IN CONTROL OF ANOPHELES PRODUCTION. South. Med. Jour. 21: 754-759, illus. [Discussion, pp. 759-760.]

(80) COQUILLET, D. W.
1903. FOUR NEW SPECIES OF CULEX. Canad. Ent. 35: 255-257.

(81) COVELL, GORDON.
[1931.] MALARIA CONTROL BY ANTI-MOSQUITO MEASURES. 148 pp., illus. Calcutta, Simla, and London.

(82) DAGGY, RICHARD H., MUEGGE, OSWALD J., and RILEY, WILLIAM A.
1941. A PRELIMINARY SURVEY OF THE ANOPHELINE MOSQUITO FAUNA OF SOUTHEASTERN MINNESOTA AND ADJACENT WISCONSIN AREAS. U. S. Pub. Health Serv. Rpts. 56: 883-895, illus.

(83) DARLING, S. T.
1925. DISCUSSION ON RELATIVE IMPORTANCE IN TRANSMITTING MALARIA OF ANOPHELES QUADRIMACULATUS, PUNCTIPENNIS, AND CRUCIANS AND ADVISABILITY OF DIFFERENTIATING BETWEEN THESE SPECIES IN APPLYING CONTROL MEASURES. South. Med. Jour. 18: 452-457. [Discussion, pp. 457-458.]

(84) DAVIS, WILLIAM A.
1940. A STUDY OF BIRDS AND MOSQUITOES AS HOSTS FOR THE VIRUS OF EASTERN EQUINE ENCEPHALOMYELITIS. Amer. Jour. Hyg. 45-59.

(85) DEONIER, CHRISTIAN C., BURRELL, R. W., MAPLE, JOHN D., and COCHRAN, J. H.
1945. DDT AS AN ANOPHELINE LARVICIDE: PRELIMINARY FIELD STUDIES. Jour. Econ. Ent. 38: 244-249.

(86) ——— CAIN, T. L., JR., and MCDUFFIE, W. C.
1950. AERIAL SPRAY TESTS ON ADULT SALT-MARSH MOSQUITOES RESISTANT TO DDT. Jour. Econ. Ent. 43: 506-510.

(87) ——— MAPLE, JOHN D., JONES, HOWARD A., HINCHEY, EDNA, and EIDE, PAUL M.
1945. DDT AS AN ANOPHELINE LARVICIDE—LABORATORY TESTS. Jour. Econ. Ent. 38: 241-243.

(88) DODGE, H. R.
1945. NOTES ON THE MORPHOLOGY OF MOSQUITO LARVAE. Ent. Soc. Amer. Ann. 38: 163-167, illus..

(89) ———
1947. A NEW SPECIES OF WYEOMYIA FROM THE PITCHER PLANT (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 49: 117-122, illus.

(90) DORER, R. E., CARTER, R. G., and BICKLEY, W. E.
1950. OBSERVATIONS ON THE PUPAE OF MANSONIA PERTURBANS (WALK.) IN VIRGINIA. N. J. Mosquito Extermin. Assoc. Proc. 37: 110-112.

(91) DOZIER, HERBERT L.
1936. OBSERVATIONS ON BREEDING PLACES AND WINTER ACTIVITIES OF MOSQUITOES IN THE VICINITY OF NEW ORLEANS, LOUISIANA. Ent. Soc. Wash. Proc. 38: 148-155, illus.

(92) DUNN, L. H.
1918. THE LAKE MOSQUITO, MANSONIA TITILLANS WALK., AND ITS HOST PLANT, PISTIA STRATIOTES LINN., IN THE CANAL ZONE, PANAMA (DIPTERA: CULICIDAE). Ent. News. 29: 260-269; 288-295.

(93) DUPREE, J. W.
1905. THE MOSQUITOES OF LOUISIANA AND THEIR PATHOGENIC POSSIBILITIES, WITH REMARKS UPON THEIR EXTERMINATION. New Orleans Med. and Surg. Jour. 58: 1-16.

(94) DYAR, HARRISON G.
1902. THE EGGS OF MOSQUITOES OF THE GENUS CULEX. Science 16: 672-673.
(95) ———
1922. THE MOSQUITOES OF THE UNITED STATES. U. S. Natl. Mus. Proc. 62, art. 1, 119 pp.
(96) ———
1928. THE MOSQUITOES OF THE AMERICAS. Carnegie Inst. Wash. Pub. 387, 616 pp., illus.
(97) ——— and BARRET, HARVEY P.
1918. DESCRIPTIONS OF HITHERTO UNKNOWN LARVAE OF CULEX (DIPTERA, CULICIDAE). Insecutor Inscitiae Menstruus 6: 119-120.
(98) ——— and KNAB, FREDERICK.
1906. THE LARVAE OF CULICIDAE CLASSIFIED AS INDEPENDENT ORGANISMS. N. Y. Ent. Soc. Jour. 14: 169-230.
(99) EADS, RICHARD B.
1946. A NEW RECORD OF ANOPHELES ALBIMANUS IN TEXAS. Jour. Econ. Ent. 39: 420.
(100) ——— and MENZIES, GEORGE C.
1950. DISTRIBUTION RECORDS OF MANSONIA BLANCHARD (DIPTERA, CULICIDAE) IN TEXAS. Mosquito News 10: 3-5.
(101) EDGAR, S. A., and WILLIAMS, O. M.
1948. EFFECT OF MOSQUITOES ON POULTRY. Poultry Sci. 27: 660.
(102) EDWARDS, F. W.
1932. DIPTERA. FAM. CULICIDAE. *In* Wytsman, P., Genera Insectorum, fasc. 194, 258 pp., illus. Bruxelles.
(103) EIDE, P. M., DEONIER, C. C., and BURRELL, R. W.
1945. DDT AS A CULICINE LARVICIDE. Jour. Econ. Ent. 38: 537-541.
(104) ENGINEERING NEWS-RECORD, EDITORS.
1936. MOSQUITO CONTROL ENGINEERING. 57 pp., illus. New York.
(105) EYLES, D. E.
1944. A CRITICAL REVIEW OF THE LITERATURE RELATING TO THE FLIGHT AND DISPERSION HABITS OF ANOPHELINE MOSQUITOES. U. S. Pub. Health Serv. Bul. 287, 39 pp.
(106) ——— and MOST, HARRY.
1947. INFECTIVITY OF PACIFIC ISLAND WUCHERERIA BANCROFTI TO MOSQUITOES OF THE UNITED STATES. Amer. Jour. Trop. Med. 27: 211–220.
(107) FARID, MOHYEDDIN AHMED.
1949. RELATIONSHIPS BETWEEN CERTAIN POPULATIONS OF CULEX PIPIENS LINNAEUS AND CULEX QUINQUEFASCIATUS SAY IN THE UNITED STATES. Amer. Jour. Hyg. 49: 83–100.
(108) FELLTON, HERMAN L.
1944. THE BREEDING OF THE SALT-MARSH MOSQUITO IN MIDWESTERN STATES. Jour. Econ. Ent. 37: 245–247.
(109) FERGUSON, FREDERICK F.
1954. BIOLOGICAL FACTORS IN THE TRANSMISSION OF AMERICAN ARTHROPOD-BORNE VIRUS ENCEPHALITIDES. A summary. U. S. Pub. Health Serv. Monog. No. 23, 37 pp.
(110) FISK, FRANK W.
1939. NEW MOSQUITO RECORDS FROM KEY WEST, FLA. (Sci Note) Jour. Econ. Ent. 32: 469.
(111) ——— and LEVAN, JAMES H.
1940. MOSQUITO COLLECTIONS AT CHARLESTON, SOUTH CAROLINA, USING THE NEW JERSEY LIGHT TRAP. (Sci. Note) Jour. Econ. Ent. 33: 578–579.
(112) FLETCHER, ORLIN K., JR., and FLANAGAN, LEON.
1957. WINTER BREEDING OF CULEX QUINQUEFASCIATUS SAY IN COLUMBUS, GEORGIA. Mosquito News 17: 29–32.
(113) FOOTE, RICHARD H.
1952. THE LARVAL MORPHOLOGY AND CHAETOTAXY OF THE CULEX SUBGENUS MELANOCONION. (DIPTERA, CULICIDAE). Ent. Soc. Amer. Ann. 45: 445–472, illus.
(114) ———
1954. THE LARVAE AND PUPAE OF THE MOSQUITOES BELONGING TO THE CULEX SUBGENERA MELANOCONION AND MOCHLOSTYRAX. U. S. Dept. Agr. Tech. Bul. 1091, 125 pp., illus.

(114a) ——— and COOK, DAVID R.
1959. MOSQUITOES OF MEDICAL IMPORTANCE. U. S. Dept. Agr., Handb. No. 152. 158 pp., illus.
(115) FREEBORN, STANLEY B.
1949. ANOPHELINES OF THE NEARCTIC REGION. *In* Boyd, Malariology, v. I, pp. 379-398.
(116) FROHNE, W. C.
1939. ANOPHELINE BREEDING: SUGGESTED CLASSIFICATION OF PONDS BASED ON CHARACTERISTIC DESMIDS. U. S. Pub. Health Serv. Rpts. 54: 1363-1387.
(117) ——— WEATHERSBEE, ALBERT A., WILLIAMS, GILES M., and HART, JOHN W.
1950. OBSERVATIONS OF THE PERSISTENCE OF PLASMODIUM INFECTIONS IN ANOPHELES MOSQUITOES IN AN AREA OF LOW OBSERVED HUMAN MALARIA PARASITEMIA IN SOUTH CAROLINA. Natl. Malaria Soc. Jour. 9: 10-24.
(118) GAHAN, JAMES B., BERTHOLF, J. H., DAVIS, A, N., JR., and SMITH, CARROLL N.
1956. FIELD TESTS WITH TWO PHOSPHOROTHIOATES AGAINST RESISTANT SALT-MARSH MOSQUITOES. Mosquito News 16: 91-93.
(119) ——— TRAVIS, B. V., and LINDQUIST, ARTHUR W.
1945. DDT AS A RESIDUAL-TYPE SPRAY TO CONTROL DISEASE-CARRYING MOSQUITOES: LABORATORY TESTS. Jour. Econ. Ent. 38: 236-240.
(120) ——— TRAVIS, B. V., MORTON, FRED A., and LINDQUIST, ARTHUR W.
1945. DDT AS A RESIDUAL-TYPE TREATMENT TO CONTROL ANOPHELES QUADRIMACULATUS: PRACTICAL TESTS. Jour. Econ. Ent. 38: 231-235.
(121) GEIGER, J. C., PURDY, W. C., and TARBETT, R. E.
1919. EFFECTIVE MALARIA CONTROL IN A RICEFIELD DISTRICT WITH OBSERVATIONS ON EXPERIMENTAL MOSQUITO FLIGHTS. Jour. Amer. Med. Assoc. 72: 844-847, illus.
(122) GILBERT, I. H., GOUCK, H. K., and SMITH, CARROLL N.
1957. NEW INSECT REPELLENT. Soap and Chem. Spec. 33(5): 115-117, 129-133; 33(6): 95, 97, 99, 109.
(123) GINSBURG, JOSEPH M.
1936. PROTECTION OF OUTDOOR GATHERINGS FROM THE MOSQUITO PEST. N. J. Mosquito Extermin. Assoc. Proc. 23: 166-173.
(124) ———
1937. PRINCIPLES UNDERLYING THE PROTECTION OF OUTDOOR MEETINGS FROM THE MOSQUITO PEST AND METHOD OF APPLICATION. N. J. Mosquito Extermin. Assoc. Proc. 24: 5-11.
(125) GJULLIN, C. M., HEGARTY, C. P., and BOLLEN, W. P.
1941. THE NECESSITY OF A LOW OXYGEN CONCENTRATION FOR THE HATCHING OF AEDES MOSQUITO EGGS. Jour. Cell. and Compar. Physiol. 17: 193-202.
(126) ——— and ISAAK, LEWIS W.
1957. PRESENT STATUS OF MOSQUITO RESISTANCE TO INSECTICIDES IN THE SAN JOAQUIN VALLEY IN CALIFORNIA. Mosquito News 17: 67-70.
(126a) GJULLIN, C. M., SAILER, R. I., STONE, ALAN, and TRAVIS, B. V.
1960. THE MOSQUITOES OF ALASKA. U. S. Dept. Agr., Agr. Handb. No. 182. [In Press.]
(127) ——— YATES, W. W., and STAGE, H. H.
1950. STUDIES ON AEDES VEXANS (MEIG.) AND AEDES STICTICUS (MEIG.), FLOOD-WATER MOSQUITOES, IN THE LOWER COLUMBIA RIVER VALLEY. Ent. Soc. Amer. Ann. 43: 262-275.
(128) GOODHUE, L. D., and SULLIVAN, W. N.
1943. METHOD OF APPLYING PARASITICIDES. U. S. Patent 2,321,303, issued June 8.
(129) GRANETT, PHILIP.
1940. STUDIES OF MOSQUITO REPELLENTS. I. TEST PROCEDURE AND METHOD OF EVALUATING TEST DATA. II. RELATIVE PERFORMANCE OF CERTAIN CHEMICALS AND COMMERCIALLY AVAILABLE MIXTURES AS MOSQUITO REPELLENTS. Jour. Econ. Ent. 33: 563-572, illus.
(130) ——— and HAYNES, HARRY L.
1945. INSECT-REPELLENT PROPERTIES OF 2-ETHYLHEXANEDIOL-1, 3. Jour. Econ. Ent. 38: 671-675.

(131) GRIFFITTS, T. H. D.
1918. WINTER HIBERNATION OF ANOPHELES LARVAE. U. S. Pub. Health Serv. Rpts. 33: 1996-1998.
(132) ———
1927. ANOPHELES ATROPOS DYAR AND KNAB. A NOTE ON ITS BREEDING AND OTHER HABITS. U. S. Pub Health Serv. Rpts. 42: 1903-1905.
(133) HAEGER, JAMES S.
1949. A REVIEW OF ANOPHELES ALBIMANUS BREEDING ON THE FLORIDA KEYS. Fla. Anti-Mosquito Assoc. Rpt., 20th Ann. Meeting, pp. 118-121.
(134) ———
1950. THE PRESENT STATUS OF ANOPHELES ALBIMANUS IN THE FLORIDA KEYS. Fla. Anti-Mosquito Assoc. Rpts., 21st Ann. Meeting, pp. 118-119.
(135) HAMMON, W. McD, and REEVES, W. C.
1943. LABORATORY TRANSMISSION OF ST. LOUIS ENCEPHALITIS VIRUS BY THREE GENERA OF MOSQUITOES. Jour. Expt. Med. 78: 241-253.
(136) ——— and REEVES, W. C.
1945. RECENT ADVANCES IN THE EPIDEMIOLOGY OF THE ARTHROPOD-BORNE VIRUS ENCEPHALITIDES INCLUDING CERTAIN EXOTIC TYPES. Amer. Jour. Pub. Health 35: 994-1004.
(137) ——— and REEVES, W. C.
1947. INTEREPIDEMIC STUDIES ON ARTHROPOD-BORNE VIRUS ENCEPHALITIDES AND POLIOMYELITIS IN KERN COUNTY, CALIFORNIA, AND THE YAKIMA VALLEY, WASHINGTON, 1944. Amer. Jour. Hyg. 46: 326-335.
(138) ——— REEVES, W. C., BENNER, S. R., and BROOKMAN, BERNARD.
1945. HUMAN ENCEPHALITIS IN THE YAKIMA VALLEY, WASHINGTON, 1942, WITH FORTY-NINE VIRUS ISOLATIONS (WESTERN EQUINE AND ST. LOUIS TYPES) FROM MOSQUITOES. Jour. Amer. Med. Assoc. 128: 1133-1139.
(139) ——— REEVES, W. C., and GALINDO, P.
1945. EPIDEMIOLOGIC STUDIES OF ENCEPHALITIS IN THE SAN JOAQUIN VALLEY OF CALIFORNIA, 1943, WITH THE ISOLATION OF VIRUSES FROM MOSQUITOES. Amer. Jour. Hyg. 42: 299-306.
(140) HARDEN, P. H.
1945. THE OCCURRENCE OF ORTHOPODOMYIA ALBA BAKER AT NEW ORLEANS, LOUISIANA. Mosquito News 5: 131.
(141) HAYES, RICHARD O., and MORLAN, HARVEY B.
1957. NOTES ON AEDES TRISERIATUS EGG INCUBATION AND COLONIZATION. Mosquito News 17: 33-36.
(142) HEADLEE, THOMAS J.
1921. THE MOSQUITOES OF NEW JERSEY AND THEIR CONTROL. N. J. Agr. Expt. Sta. Bul. 348, 229 pp., illus.
(143) ———
1934. MOSQUITO WORK IN NEW JERSEY FOR THE YEAR 1933. N. J. Mosquito Extermin. Assoc. Proc. 21: 8-37.
(144) ———
1941. NEW JERSEY MOSQUITO PROBLEMS. N. J. Mosquito Extermin. Assoc. Proc. 28: 7-12.
(145) ———
1945. THE MOSQUITOES OF NEW JERSEY AND THEIR CONTROL. 326 pp Rutgers Univ. Press, New Brunswick, N. J.
(146) HEDEEN, R. A.
1953. THE BIOLOGY OF THE MOSQUITO AEDES ATROPALPUS (COQUILLET). Kans. Ent. Soc. Jour. 26: 1-10.
(147) ———
1954. THE IDENTIFICATION OF THE LARVA OF PSOROPHORA (GRABHAMIA) SIGNIPENNIS (COQUILLETT). Mosquito News 14: 143-145.
(148) HERMS, WILLIAM BRODBECK, and GRAY, HAROLD FARNSWORTH.
1944. MOSQUITO CONTROL—PRACTICAL METHODS FOR ABATEMENT OF DISEASE VECTORS AND PESTS. 419 pp., illus. Oxford University Press. New York.
(149) HINMAN, E. HAROLD.
1930. A STUDY OF THE FOOD OF MOSQUITO LARVAE (CULICIDAE). Amer. Jour. Hyg. 12: 238-270.

(150) ———
1931. THE WINTER BREEDING AND ACTIVITY OF CULICINE MOSQUITOES AT NEW ORLEANS (30° N. LAT.) Amer. Jour. Trop. Med. 11: 459-467, illus.
(151) ———
1932. A DESCRIPTION OF THE LARVA OF ANOPHELES ATROPOS D. & K. WITH BIOLOGICAL NOTES ON THE SPECIES. Ent. Soc. Wash. Proc. 34: 138-142.
(152) ———
1934. PREDATORS OF THE CULICIDAE (MOSQUITOES). I.—THE PREDATORS OF LARVAE AND PUPAE, EXCLUSIVE OF FISH. Jour. Trop. Med. and Hyg. [London] 37: 129-134.
(153) ———
1934. PREDATORS OF THE CULICIDAE (MOSQUITOES). II.—PREDATORS OF ADULT MOSQUITOES. Jour. Trop. Med. and Hyg. [London] 37: [145]-150.
(154) ———
1935. BIOLOGICAL NOTES ON URANOTAENIA SPP. IN LOUISIANA (CULICIDAE, DIPTERA). Ent. Soc. Amer. Ann. 28: 404-407.
(155) ———
1938. BIOLOGICAL EFFECTS OF FLUCTUATION OF WATER LEVEL ON ANOPHELINE BREEDING. Amer. Jour. Trop. Med. 18: 483-495, illus.
(156) HORSFALL, W. R.
1936. OCCURRENCE AND SEQUENCE OF MOSQUITOES IN SOUTHEASTERN ARKANSAS IN 1935. Jour. Econ. Ent. 29: 676-679.
(157) ———
1937. MOSQUITOES OF SOUTHEASTERN ARKANSAS. Jour. Econ. Ent. 30: 743-748.
(158) ———
1939. HABITS OF AEDES THIBAULTI DYAR AND KNAB (DIPTERA, CULICIDAE). Kans. Ent. Soc. Jour. 12: 70-71.
(159) ———
1942. BIOLOGY AND CONTROL OF MOSQUITOES IN THE RICE AREA. Ark. Agr. Expt. Sta. Bul. 427: 1-46.
(160) ———
1955. MOSQUITOES, THEIR BIONOMICS AND RELATION TO DISEASE. 723 pp. The Ronald Press, New York.
(161) ——— MILES, ROBERT C., and SOKATCH, JOHN T.
1952. EGGS OF FLOODWATER MOSQUITOES. I.—SPECIES OF PSOROPHORA. Ent. Soc. Amer. Ann. 45: 618-624.
(162) HOWARD, L. O.
1921. [MOSQUITO WORK AT MOUND, LA.] N. J. Mosquito Extermin. Assoc. Proc. 8: 75-83, illus.
(163) ——— DYAR, HARRISON G., and KNAB, FREDERICK.
1912-17. THE MOSQUITOES OF NORTH AND CENTRAL AMERICA AND THE WEST INDIES. Carnegie Inst. Wash. Pub. 159. 4 v., illus. Washington, D. C.
(164) HOWITT, B. F., DODGE, H. R., BISHOP, L. K., and GORRIE, R. H.
1949. RECOVERY OF THE VIRUS OF EASTERN EQUINE ENCEPHALOMYELITIS FROM MOSQUITOES (MANSONIA PERTURBANS) COLLECTED IN GEORGIA. Science 110: 141-142.
(165) HU, S. M. K.
1931. STUDIES ON HOST-PARASITE RELATIONSHIPS OF DIROFILARIA IMMITIS LEIDY AND ITS CULICINE INTERMEDIATE HOSTS. Amer. Jour. Hyg. 14: 614-629.
(166) HUFF, CLAY G.
1929. OVULATION REQUIREMENTS OF CULEX PIPIENS LINN. Mar. Biol. Lab., Woods Hole, Mass. Biol. Bul. 56: 347-350.
(167) HUFFAKER, CARL B., and BACK, RICHARD C.
1943. A STUDY OF METHODS OF SAMPLING MOSQUITO POPULATIONS. Jour. Econ. Ent. 36: 561-569.
(168) HULSE, F. E.
1922. SKETCH MAPPING FOR HEALTH PROBLEMS. Amer. Jour. Pub. Health 12: 1034-1038, illus.
(169) HURLBUT, HERBERT S.
1938. A STUDY OF THE LARVAL CHAETOTAXY OF ANOPHELES WALKERI THEOBALD. Amer. Jour. Hyg. 28: 149-173, illus.

(170) ———
1938. FURTHER NOTES ON THE OVERWINTERING OF THE EGGS OF ANOPHELES WALKERI THEOBALD WITH A DESCRIPTION OF THE EGGS. Jour. Parasitol. 24: 521-526, illus.
(171) HUSMAN, C. N.
1953. A LIGHT PNEUMATIC SPRAYER FOR INSTALLATION ON VEHICLES. Mosquito News 13: 134-138.
(172) IRONS, J. V.
1956. MOSQUITO-BORNE DISEASES IN TEXAS. Mosquito News 16: 64-66.
(173) JENKINS, DALE W.
1949. TOXORHYNCHITES MOSQUITOES OF THE UNITED STATES (DIPTERA, CULICIDAE). Ent. Wash. Proc. 51: 225-229, illus.
(174) ——— and CARPENTER, STANLEY J.
1946. ECOLOGY OF THE TREE HOLE BREEDING MOSQUITOES OF NEARCTIC NORTH AMERICA. Ecol. Monog. 16: 33-47, illus.
(175) JOHNSON, H. A.
1936. NOTES ON THE OCCURRENCE OF A. WALKERI. South. Med. Jour. 29: 856-857.
(176) KARSTAD, L. H., FLETCHER, O. K., SPALATIN, J., ROBERTS, R., and HANSON, R. P.
1957. EASTERN EQUINE ENCEPHALOMYELITIS VIRUS ISOLATED FROM THREE SPECIES OF DIPTERA FROM GEORGIA. Science 125: 395-396.
(177) KARTMAN, L.
1954. FREQUENCY AND INTENSITY OF DIROFILARIA IMMITIS INFECTIONS IN MOSQUITOES. Expt. Parasitol. 3: 25-29.
(178) KEEFE, B. F., and BEADLE, L. D.
1956. A DIGEST OF STATE ENABLING LEGISLATION FOR MOSQUITO ABATEMENT THROUGH 1955. U. S. Dept. of Health, Education, and Welfare, Pub. Health Serv., Communicable Disease Center Pub., 83 pp., (processed).
(179) KELLER, J. C., CHAPMAN, H. C., and LABRECQUE, G. C.
1954. TESTS WITH GRANULATED INSECTICIDES FOR THE CONTROL OF SALT-MARSH MOSQUITO LARVAE. Mosquito News 14: 5-9.
(180) KELSER, R. A.
1933. MOSQUITOES AS VECTORS OF THE VIRUS OF EQUINE ENCEPHALOMYELITIS. Amer. Vet. Med. Assoc. Jour. 82: 767-771.
(181) KIKER, CALVIN C., FAIRER, CHARLES D., and FLANERY, PAUL N.
1938. FURTHER OBSERVATIONS ON AIRPLANE DUSTING FOR ANOPHELES LARVAL CONTROL. South. Med. Jour. 31: 808-813, illus.
(182) KING, W. V.
1924. ANOPHELINE INFECTION UNDER NATURAL CONDITIONS. South. Med. Jour. 17: 596-597.
(183) ———
1928. THE ANOPHELES DENSITY INDEX IN MALARIA RESEARCH AND CONTROL WORK. South. Med. Jour. 21: 763-767, illus.
(184) ———
1937. ON THE DISTRIBUTION OF ANOPHELES ALBIMANUS AND ITS OCCURRENCE IN THE UNITED STATES. South. Med. Jour. 30: 943-946.
(185) ———
1939. VARIETIES OF ANOPHELES CRUCIANS WIED. Amer. Jour. Trop. Med. 19: 461-471, illus.
(186) ——— Compiler.
1954. CHEMICALS EVALUATED AS INSECTICIDES AND REPELLENTS AT ORLANDO, FLA. U. S. Dept. Agr., Agr. Handb. 69, 397 pp.
(187) ——— and BRADLEY, G. H.
1926. AIRPLANE DUSTING IN THE CONTROL OF MALARIA MOSQUITOES. U. S. Dept. Agr. Cir. 367, 16 pp., illus.
(188) ——— and BRADLEY, G. H.
1926. AIRPLANE DUSTING IN THE CONTROL OF MALARIA MOSQUITOES. Jour. Trop. Med. and Hyg. [London] 29: 311-313, illus.
(189) ——— and BRADLEY, G. H.
1937. NOTES ON CULEX ERRATICUS AND RELATED SPECIES IN THE UNITED STATES (DIPTERA, CULICIDAE). Ent. Soc. Amer. Ann. 30: 345-357, illus.

(190) ——— and BRADLEY, G. H.
1941. GENERAL MORPHOLOGY OF ANOPHELES AND CLASSIFICATION OF THE NEARCTIC SPECIES. *In* Human Malaria. Amer. Assoc. Adv. Sci. Pub. 15, pp. 63–70, illus.

(191) ——— and BRADLEY, G. H.
1941. DISTRIBUTION OF THE NEARCTIC SPECIES OF ANOPHELES. *In* Human Malaria. Amer. Assoc. Adv. Sci. Pub. 15, pp. 71–78, illus.

(192) ——— BRADLEY, G. H., and MC NEEL, T. E.
1937. EXPERIMENTS IN FLORIDA IN REPELLING MOSQUITOES BY OUTDOOR SPRAYING. N. J. Mosquito Extermin. Assoc. Proc. 24: 163–172.

(193) ——— BRADLEY, G. H., and MCNEEL, T. E.
1944. THE MOSQUITOES OF THE SOUTHEASTERN STATES. U. S. Dept. Agr. Misc. Pub. 336, rev. 96 pp., illus. [Originally published in 1939; revised 1942 and 1944.]

(194) ——— and BULL, CAROLL G.
1923. THE BLOOD FEEDING HABITS OF MALARIA-CARRYING MOSQUITOES. Amer. Jour. Hyg. 3: 497–513, illus.

(195) ——— ROTH, LOUIS, TOFFALETI, JAMES, and MIDDLEKAUFF, WOODROW W.
1943. NEW DISTRIBUTION RECORDS FOR THE MOSQUITOES OF THE SOUTHEASTERN UNITED STATES DURING 1942. Jour. Econ. Ent. 36: 573–577.

(196) KISSLING, R. E., CHAMBERLAIN, R. W., NELSON, D. B., and STAMM, D. D.
1955. STUDIES ON THE NORTH AMERICAN ARTHROPOD-BORNE ENCEPHALITIDES. VIII.—EQUINE ENCEPHALITIS STUDIES IN LOUISIANA. Amer. Jour. Hyg. 62 (3): 233–254, illus.

(197) ——— and RUBIN, H.
1950. EASTERN EQUINE ENCEPHALOMYELITIS. U. S. Dept. of Health, Education, and Welfare, Communicable Disease Center Bul. 9: 2–5.

(198) KITCHEN, S. F., and BRADLEY, G. H.
1936. ANOPHELES WALKERI THEOBALD AS A VECTOR OF PLASMODIUM FALCIPARUM (WELCH). Amer. Jour. Trop. Med. 16: 579–581.

(199) KITZMILLER, J. B.
1952. INBRED STRAINS OF CULEX MOSQUITOES. Science 116: 66-67.

(200) KLIGLER, I. J., MUCKENFUSS, R. S., and RIVERS, T. M.
1929. TRANSMISSION OF FOWL-POX BY MOSQUITOES. Jour. Expt. Med. 49: 649–660.

(201) KNIGHT, KENNETH L.
1951. A REVIEW OF THE CULEX PIPIENS COMPLEX IN THE MEDITERRANEAN SUBREGION (DIPTERA, CULICIDAE). *In* Mattingly *et al.*, The *Culex pipiens* Complex. Royal Ent. Soc., London, Trans. 102: 354-364.

(202) ———
1954. MOSQUITO LIGHT TRAP COLLECTIONS AT YUKON, FLORIDA, FOR THE SIX-YEAR PERIOD, 1948-1953. N. J. Mosquito Extermin. Assoc. Proc. 41: 251–257.

(203) ———
1954. A COMPARISON OF THE NEW JERSEY LIGHT TRAP AND THE DAYTIME RESTING STATION SAMPLING METHODS FOR THE DETERMINATION OF THE ABUNDANCE OF AEDES INFIRMATUS D. & K. ADULTS. Fla. Anti-Mosquito Assoc. Rpt., 25th Ann. Meeting, pp. 100-104, illus. [Mimeographed.]

(204) KNIPLING, E. F.
1945. THE DEVELOPMENT AND USE OF DDT FOR THE CONTROL OF MOSQUITOES. Natl. Malaria Soc. Jour. 4: 77–92.

(205) KOMP, W. H. W.
1926. OBSERVATIONS ON ANOPHELES WALKERI AND ANOPHELES ATROPOS (DIPTERA, CULICIDAE). Insecutor Inscitiae Menstruus 14: 168–176.

(206) KUMM, HENRY W.
1929. STUDIES IN THE DISPERSION OF ANOPHELES MOSQUITOES. Amer. Jour. Trop. Med. 9: 67–77, illus.

(207) LE PRINCE, J. A. A., and GRIFFITTS, T. H. D.
1917. FLIGHT OF MOSQUITOES. STUDIES ON THE DISTANCE OF FLIGHT OF ANOPHELES QUADRIMACULATUS. U.S. Pub. Health Serv. Rpts. 32: 656-659, illus.
(208) MACCREARY, DONALD.
1941. COMPARATIVE DENSITY OF MOSQUITOES AT GROUND LEVEL AND AT AN ELEVATION OF APPROXIMATELY ONE-HUNDRED FEET. Jour. Econ. Ent. 34: 174-179, illus.
(209) ——— and STEARNS, L. A.
1937. MOSQUITO MIGRATION ACROSS DELAWARE BAY. N. J. Mosquito Extermin. Assoc. Proc. 24: 188-197, illus.
(210) MCNEEL, T. E.
1931. A METHOD FOR LOCATING THE LARVAE OF THE MOSQUITO MANSONIA. Science 74: 155.
(211) ———
1932. OBSERVATIONS ON THE BIOLOGY OF MANSONIA PERTURBANS (WALK.) DIPTERA, CULICIDAE. N. J. Mosquito Extermin. Assoc. Proc. 19: 91-96, illus.
(212) MATHESON, ROBERT.
1930. THE UTILIZATION OF AQUATIC PLANTS AS AIDS IN MOSQUITO CONTROL. Amer. Nat. 64: 56-86, illus.
(213) ———
1944. A HANDBOOK OF THE MOSQUITOES OF NORTH AMERICA. 314 pp. Comstock Pub. Assoc., Ithaca, N. Y.
(214) ——— BOYD, MARK F., and STRATMAN-THOMAS, WARREN K.
1933. ANOPHELES WALKERI, THEOBALD, AS A VECTOR OF PLASMODIUM VIVAX, GRASSI AND FELETTI. Amer. Jour. Hyg. 17: 515-516.
(215) ——— and HURLBUT, H. S.
1937. NOTES ON ANOPHELES WALKERI THEOBALD. Amer. Jour. Trop. Med. 17: 237-243, illus.
(216) ——— BRUNETT, E. L., and BRODY, A. L.
1931. THE TRANSMISSION OF FOWL-POX BY MOSQUITOES, PRELIMINARY REPORT. Poultry Science 10: 211-223.
(217) MATTINGLY, P. F.
1956. SPECIES HYBRIDS IN MOSQUITOES. Roy. Ent. Soc., London, Trans. 108: 21-36.
(218) ——— ROZEBOOM, L. E., KNIGHT, K. L., LAVEN, H., DRUMMOND, F. H., CHRISTOPHERS, S. R., and SHUTE, P. G.
1951. THE CULEX PIPIENS COMPLEX. Roy. Ent. Soc., London, Trans. 102: 331-382, illus.
(219) ——— SHUTE, P. G., LAVEN, H., and KNIGHT, K. L.
1953. THE CULEX PIPIENS COMPLEX. Trans. IXth International Congress Ent. II: 283-300, illus.
(220) MAYNE, BRUCE.
1926. REPORT OF A SURVEY TO DETERMINE THE MALARIA PREVALENCE IN THE OKEFENOKEE SWAMP. U.S. Pub. Health Serv. Rpts. 41: 1652-1660, illus.
(221) ——— and GRIFFITTS, T. H. D.
1931. ANOPHELES ATROPOS D. AND K.—A NEW POTENTIAL CARRIER OF MALARIA ORGANISMS. U. S. Pub. Health Serv. Rpts. 46: 3107-3115, illus.
(222) MELENEY, HENRY E., BISHOP, EUGENE L., and ROBERTS, FRANK L.
1929. OBSERVATIONS ON THE MALARIA PROBLEM OF WEST TENNESSEE. South. Med. Jour. 22: 382-394, illus.
(223) MERRILL, MALCOLM H., LACAILLADE, C. WM., and TEN BROECK, CARL.
1934. MOSQUITO TRANSMISSION OF EQUINE ENCEPHALOMYELITIS. Science 80: 251-252.
(224) MICHENER, CHARLES D.
1945. SEASONAL VARIATIONS IN CERTAIN SPECIES OF MOSQUITOES (DIPTERA, CULICIDAE). Jour. N. Y. Ent. Soc. 53: 293-300.
(225) ———
1947. MOSQUITOES OF A LIMITED AREA IN SOUTHERN MISSISSIPPI. Amer. Mid. Nat. 37: 325-374.
(226) MIDDLEKAUFF, WOODROW W.
1944. A NEW SPECIES OF AEDES FROM FLORIDA (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 46: 42-44.

(227) ———
1944. A RAPID METHOD FOR MAKING PERMANENT MOUNTS OF MOSQUITO LARVAE. Science 99: 206.
(228) ——— and CARPENTER, STANLEY J.
1944. NEW DISTRIBUTION RECORDS FOR THE MOSQUITOES OF THE SOUTHEASTERN UNITED STATES IN 1943. Jour. Econ. Ent. 37: 88–92.
(229) MILES, VIRGIL I.
1945. DIFFERENTIATING THE LARVAE OF ANOPHELES GEORGIANUS KING, A. BRADLEYI KING, AND A. PUNCTIPENNIS (SAY). Natl. Malaria Soc. Jour. 4: 235–242.
(230) ——— and RINGS, ROY W.
1946. DISTRIBUTION RECORDS FOR MOSQUITOES OF THE SOUTHEASTERN STATES IN 1945. Jour. Econ. Ent. (Sci. Note) 39: 387–391.
(231) MULHERN, THOMAS D.
1953. BETTER RESULTS WITH MOSQUITO LIGHT TRAPS THROUGH STANDARDIZING MECHANICAL PERFORMANCE. Mosquito News 13: 130–133.
(232) MULRENNAN, JOHN A.
1946. SOME NEW RECORDS OF FLORIDA MOSQUITOES. Fla. Anti-Mosquito. Assoc. Rpt., 17th Ann. Meeting, pp. 23-24. [Mimeographed.]
(233) NATIONAL MALARIA COMMITTEE, SUBCOMMITTEE ON ENGINEERING.
1936. MALARIA CONTROL FOR ENGINEERS. U. S. Pub. Health Serv., B-1210, 81 pp., illus. [Processed.]
(234) NELSON, D. B., and CHAMBERLAIN, R. W.
1955. A LIGHT TRAP AND MECHANICAL ASPIRATOR OPERATING ON DRY CELL BATTERIES. Mosquito News 15: 28–32.
(235) NEWTON, W. L., and PRATT, I.
1946. EXPERIMENTS TO DETERMINE POTENTIAL MOSQUITO VECTORS OF WUCHERERIA BANCROFTI IN THE CONTINENTAL UNITED STATES. Amer. Jour. Trop. Med. 26: 699–706.
(236) ——— WRIGHT, WILLARD H., and PRATT, IVAN.
1945. EXPERIMENTS TO DETERMINE POTENTIAL MOSQUITO VECTORS OF WUCHERERIA BANCROFTI IN THE CONTINENTAL UNITED STATES. Amer. Jour. Trop. Med. 25: 253–261.
(237) NIELSEN, ERIK TETENS, and HAEGER, JAMES S.
1953. SWARMING AND MATING OF MOSQUITOES. Fla. Anti-Mosquito Assoc. Rpt. 24th Ann. Meeting, pp. 65–69. [Mimeographed.]
(238) ——— and HAEGER, J. S.
1954. PUPATION AND EMERGENCE IN AEDES TAENIORHYNCHUS (WIED). Bul. Ent. Res. 45: 757–768.
(239) ——— and NIELSEN, ASTRID TETENS.
1953. FIELD OBSERVATIONS ON THE HABITS OF AEDES TAENIORHYNCHUS. Ecology 34: 141–156.
(240) NORRIS, MARJORIE.
1946. RECOVERY OF A STRAIN OF EQUINE ENCEPHALITIS VIRUS FROM CULEX RESTUANS (THEOB.) (DIPTERA, CULICIDAE). Canad. Jour. Res., E, 24: 63–70.
(241) O'CONNOR, F. W., and HULSE, CONSTANCE R.
1935. STUDIES IN FILARIASIS. Puerto Rico Jour. Pub. Health 11: 167–272.
(242) OWEN, WILLIAM B.
1942. THE BIOLOGY OF THEOBALDIA INORNATA WILLISTON, IN CAPTIVE COLONY. Jour. Econ. Ent. 35: 903–907.
(243) PENNEBAKER, FAITH.
1938. ORTHOPODOMYIA ALBA IN LOUISIANA. Tulane Buggist 2: 4.
(244) PEREZ, MANUEL.
1930. AN ANOPHELINE SURVEY OF THE STATE OF MISSISSIPPI. Amer. Jour. Hyg. 11: 696–710, illus.
(245) PETERSON, ALLAN G., and SMITH, WILLIAM W.
1945. OCCURRENCE AND DISTRIBUTION OF MOSQUITOES IN MISSISSIPPI. Jour. Econ. Ent. 38: 378–383.
(246) PHILEN, E. A., and CARMICHAEL, G. T.
1956. THE MANAGEMENT OF WATER FOR MOSQUITO CONTROL IN THE COASTAL MARSHES OF FLORIDA. Mosquito News 16: 126–129.

(247) PHILLIPS, J. H.
1939. STUDIES ON THE TRANSMISSION OF DIROFILARIA IMMITIS IN MASSACHUSETTS. Amer. Jour. Hyg. 29: 121-129.
(248) PISTEY, WARREN R.
1956. STUDIES ON THE MOSQUITO TRANSMISSION OF DIROFILARIA TENUIS CHANDLER, 1942. Jour. Parasitol. 42 (Sect. 2): 16.
(249) PRATT, HARRY D.
1945. MANSONIA INDUBITANS DYAR AND SHANNON—A NEW MOSQUITO ADDITION TO THE UNITED STATES FAUNA. Kans. Ent. Soc. Jour. 18: 121-129.
(250) ——— and SEABROOK, E. L.
1952. THE OCCURRENCE OF CULEX IOLAMBDIS DYAR IN FLORIDA AND PUERTO RICO, WITH A DESCRIPTION OF THE LARVA (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 54: 27-32.
(251) ——— WIRTH, W. W., and DENNING, D. G.
1945. THE OCCURRENCE OF CULEX OPISTHOPUS KOMP IN PUERTO RICO AND FLORIDA, WITH A DESCRIPTION OF THE LARVA (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 47: 245-251.
(252) PRITCHARD, A. E., SEABROOK, E. L., and MULRENNAN, J. A.
1947. THE MOSQUITOES OF THE FLORIDA KEYS. Fla. Ent. 30: 8-15.
(253) ——— SEABROOK, E. L., and PROVOST, M. W.
1946. THE POSSIBLE ENDEMICITY OF ANOPHELES ALBIMANUS IN FLORIDA. Mosquito News 6: 183-184.
(254) PROVOST, MAURICE W.
1951. RELATIVE NUMBERS OF AEDES TAENIORHYNCHUS AND AEDES SOLLICITANS IN FLORIDA DURING RECENT YEARS. Fla. Anti-Mosquito Assoc. Rpt., 22nd Ann. Meeting, Sect. 10, not paged. [Mimeographed.]
(255) ———
1951. THE OCCURRENCE OF SALT MARSH MOSQUITOES IN THE INTERIOR OF FLORIDA. Fla. Ent. 34: 48-53.
(256) ———
1952. THE DISPERSAL OF AEDES TAENIORHYNCHUS. I.—PRELIMINARY STUDIES. Mosquito News 12: 174-190, illus.
(257) ———
1952. GROUND SPACE SPRAYING OF MANSONIA AND OTHER MOSQUITOES IN LEESBURG, FLORIDA. Mosquito News 12: 16-27, illus.
(258) ———
1955. LEESBURG MOSQUITO-SAMPLING STUDIES IN 1954. Fla. Anti-Mosquito Assoc. Rpt., 26th Ann. Meeting, pp. 112-119, illus. [Mimeographed.]
(259) QUARTERMAN, K. D., and HESS, A. D.
1950. CURRENT INVESTIGATIONS ON MOSQUITO CONTROL. Fla. Anti-Mosquito Assoc. Rpt., 21st Ann. Meeting, pp. 49-52. [Mimeographed.]
(260) QUINBY, G. E.
1941. ADDITIONS TO THE MOSQUITOES (CULICIDAE) OF THE REELFOOT LAKE REGION. Jour. Tenn. Acad. Sci. 16 (1): 17-21.
(261) REEVES, W. C., and HAMMON, W. McD.
1944. FEEDING HABITS OF THE PROVEN AND POSSIBLE MOSQUITO VECTORS OF WESTERN EQUINE AND ST. LOUIS ENCEPHALITIS IN THE YAKIMA VALLEY, WASHINGTON. Amer. Jour. Trop. Med. 24: 131-134.
(262) ——— HAMMON, WILLIAM McD., and IZUMI, ERNEST M.
1942. EXPERIMENTAL TRANSMISSION OF ST. LOUIS ENCEPHALITIS VIRUS BY CULEX PIPIENS LINNEAUS. Soc. Expt. Biol. and Med. Proc. 50: 125-128.
(263) REMINGTON, C. L.
1945. THE FEEDING HABITS OF URANOTAENIA LOWII THEOBALD (DIPTERA, CULICIDAE). Ent. News 56: 32-37; 64-68.
(264) RICHARDS, A. G. JR.
1941. A STENOGAMIC AUTOGENOUS STRAIN OF CULEX PIPIENS L. IN NORTH AMERICA (DIPTERA, CULICIDAE). Ent. News 52: 211-216.
(265) RINGS, ROY W., and HILL, SAMUEL O.
1946. THE LARVA OF AEDES (OCHLEROTATUS) MATHESONI MIDDLEKAUFF (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 48: 237-240.

(266) ——— and HILL, SAMUEL O.
1948. THE TAXONOMIC STATUS OF AEDES MATHESONI (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 50: 41-49, illus.

(267) ROCKEFELLER FOUNDATION, INTERNATIONAL HEALTH BOARD.
1924. THE USE OF FISH FOR MOSQUITO CONTROL. 120 pp., illus. New York.

(267a) ROGERS, ANDREW J., and RATHBURN, CARLISLE B., JR.
1958. TESTS WITH A NEW GRANULAR PARIS GREEN FORMULATION AGAINST AEDES, ANOPHELES, AND PSOROPHORA LARVAE. Mosquito News 18: 90-93. *Also in* Fla. Anti-Mosquito Assoc. Rpt., 30th Ann. Meeting, pp. 28-31. 1959.

(268) ROOT, FRANCIS METCALF.
1924. NOTES ON THE MOSQUITOES OF LEE COUNTY, GEORGIA. Amer. Jour. Hyg. 4: 449-455.

(269) ROSS, EDWARD S.
1943. THE IDENTITY OF AEDES BIMACULATUS (COQUILLETT) AND A NEW SUBSPECIES OF AEDES FULVUS (WIEDMANN) FROM THE UNITED STATES (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 45: 143-151.

(270) ROSS, HERBERT H.
1947. THE MOSQUITOES OF ILLINOIS (DIPTERA, CULICIDAE). Ill. Nat. Hist. Surv. Bul. 24: 1-96.

(271) ROTH, LOUIS M.
1944. A KEY TO THE ANOPHELES OF THE SOUTHEASTERN UNITED STATES, BY MALE GENITALIA (DIPTERA, CULICIDAE). Amer. Mid. Nat. 31: 96-110.

(272) ———
1945. ABERRATIONS AND VARIATIONS IN ANOPHELINE LARVAE OF THE SOUTHEASTERN UNITED STATES (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 47: 257-278.

(273) ———
1945. THE MALE AND LARVA OF PSOROPHORA (JANTHINOSOMA) HORRIDA (DYAR AND KNAB) AND A NEW SPECIES OF PSOROPHORA FROM THE UNITED STATES (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 47: 1-23.

(274) ——— and YOUNG, FRANK N.
1944. CULEX (MELANOCONION) ATRATUS THEOBALD IN FLORIDA; A NEW CONTINENTAL NORTH AMERICAN RECORD, WITH NOTES ON THE OTHER MELANOCONIONS OF THE SOUTHEASTERN UNITED STATES. Ent. Soc. Amer. Ann. 37: 84-88.

(275) ROZEBOOM, L. E.
1942. THE MOSQUITOES OF OKLAHOMA.—Okla. Agr. Expt. Sta. Tech. Bul. No. T-16, 56 pp.

(276) ———
1951. THE CULEX PIPIENS COMPLEX IN NORTH AMERICA. *In* Mattingly et. al., The *Culex pipiens* Complex. Royal Ent. Soc., London, Trans. 102: 343-353, illus.

(277) ——— and GILFORD, BARBARA N.
1954. SEXUAL ISOLATION BETWEEN POPULATIONS OF THE CULEX PIPIENS COMPLEX IN NORTH AMERICA. Jour. Parasitol. 40: 237-244.

(278) ——— and KOMP, WILLIAM H. W.
1950. A REVIEW OF THE SPECIES OF CULEX OF THE SUBGENUS MELANOCONION (DIPTERA, CULICIDAE). Ent. Soc. Amer. Ann. 43: 75-114, illus.

(279) RUSSELL, P. F.
1925. IDENTIFICATION OF THE LARVAE OF THE THREE COMMON ANOPHELINE MOSQUITOES OF THE SOUTHERN UNITED STATES. Amer. Jour. Hyg. 5: 149-174.

(280) SABROSKY, C. W., MCDANIEL, G. E., and REIDER, R. F.
1946. A HIGH RATE OF NATURAL PLASMODIUM INFECTION IN ANOPHELES CRUCIANS. Science 104: 247-248.

(281) SCHOOF, H. F., and ASHTON, D. F.
1944. NOTES AND NEW DISTRIBUTION RECORDS ON THE MOSQUITOES OF NORTH CAROLINA. Elisha Mitchell Sci. Soc. Jour. 60: 1-10.

(282) SCHWARDT, H. H.
1939. BIOLOGIES OF ARKANSAS RICE FIELD MOSQUITOES. Ark. Agr. Expt. Sta. Bul. 377, pp. 1-22.

(283) SEABROOK, EDWIN L.
1949. OBSERVATIONS ON MANSONIA MOSQUITOES IN SOUTHEAST FLORIDA. Newell Ent. Soc. Jour. 4: 27-30.

(284) ——— and DUFFEY, T. E.
1946. THE OCCURRENCE OF MEGARHINUS RUTILUS COQUILLETT IN S. E. FLORIDA. Mosquito News 6: 193-194.

(285) SEAMAN, ELWOOD A.
1945. AN INSECT LIGHT TRAP FOR USE WITH AUTO VEHICLES IN THE FIELD. Mosquito News 5: 79-81, illus.

(286) SHEPPARD, RAYMOND R.
1949. THE MOSQUITOES OF THE SOUTHWEST COAST OF FLORIDA. Fla. Anti-Mosquito Assoc. Rpt., 20th Ann. Meeting, pp. 122-126. [Mimeographed.]

(287) SHIELDS, S. E.
1938. TENNESSEE VALLEY MOSQUITO COLLECTIONS. Jour. Econ. Ent. 31: 426-430.

(288) ——— and LACKEY, JAMES B.
1938. CONDITIONS AFFECTING MOSQUITO BREEDING, WITH SPECIAL REFERENCE TO AEDES THIBAULTI DYAR AND KNAB (DIPTERA, CULICIDAE). Jour. Econ. Ent. 31: 95-102, illus.

(289) ——— and MILES, VIRGIL I.
1937. THE OCCURRENCE OF ORTHOPODOMYIA ALBA IN ALABAMA (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 39: 237.

(290) SHLAIFER, A., and HARDING, D. E.
1946. THE MOSQUITOES OF TENNESSEE. Tenn. Acad. Sci. Jour. 21: 241-256.

(291) SHUTE, P. G.
1951. CULEX MOLESTUS. Royal Ent. Soc., London, Trans. 102: 380-382. (*In* Mattingly et al., ref. No. 218.)

(292) SMITH, JOHN B.
1904. REPORT OF THE NEW JERSEY STATE AGRICULTURAL EXPERIMENT STATION UPON THE MOSQUITOES OCCURRING WITHIN THE STATE, THEIR HABITS, LIFE HISTORY, ETC. 482 pp., illus. Trenton.

(293) SNOW, W. E.
1949. STUDIES ON PORTABLE RESTING STATIONS FOR ANOPHELES QUADRIMACULATUS IN THE TENNESSEE VALLEY. Natl. Malaria Soc. Jour. 8: 336-343, illus.

(294) ——— and PICKARD, EUGENE.
1956. SEASONAL HISTORY OF CULEX TARSALIS AND ASSOCIATED SPECIES IN LARVAL HABITATS OF THE TENNESSEE VALLEY REGION. Mosquito News 16: 143-148.

(295) STAEBLER, ARTHUR E., and BUREN, WILLIAM F.
1946. AEDES TORTILIS (THEOBALD), A MOSQUITO NEW TO THE UNITED STATES. U. S. Pub. Health Serv. Rpts. 61: 685.

(296) STAGE, H. H., GJULLIN, C. M., and YATES, W. W.
1937. FLIGHT RANGE AND LONGEVITY OF FLOODWATER MOSQUITOES IN THE LOWER COLUMBIA RIVER VALLEY. Jour. Econ. Ent. 30: 940-945.

(297) STONE, ALAN.
1953. THE HALTERES OF ANOPHELES WALKERI THEOBALD. Mosquito News 13: 209-210.

(298) ———
1957. CORRECTIONS IN THE TAXONOMY AND NOMENCLATURE OF MOSQUITOES. Ent. Soc. Wash. Proc. [1956] 58: 333-344.

(298a) ——— KNIGHT, K. L., and STARCKE, H.
1959. A SYNOPTIC CATALOGUE OF THE MOSQUITOES OF THE WORLD. Ent. Soc. Amer. (The Thomas Say Foundation.) 358 pp.

(299) STOUGH, B. DOLORES, KING, MARY ANN, and EYLES, DON E.
1949. EXTENSION OF KNOWN RANGE OF AEDES ATROPALPUS (COQUILLET) SOUTHEASTWARD INTO GEORGIA. Mosquito News 9: 173.

(300) STRATMAN-THOMAS, W. K., and BAKER, F. C.
1936. ANOPHELES BARBERI COQUILLET, AS A VECTOR OF PLASMODIUM VIVAX GRASSI AND FELETTI. Amer. Jour. Hyg. 24: 182-183.

(301) STROMQUIST, W. G.
1935. MALARIA CONTROL IN THE TENNESSEE VALLEY. Civ. Engin. 5: 771-774, illus.

(302) SUNDARARAMAN, S.
1949. BIOMETRICAL STUDIES ON INTERGRADATION IN THE GENITALIA OF CERTAIN POPULATIONS OF CULEX PIPIENS AND CULEX QUINQUEFASCIATUS IN THE UNITED STATES. Amer. Jour. Hyg. 50: 307-314.

(303) THIBAULT, JAMES K., JR.
1910. NOTES ON THE MOSQUITOES OF ARKANSAS [DIPTERA, CULICIDAE]. Ent. Soc. Wash. Proc. 12: 13-26.

(304) THOMPSON, GEORGE A., HOWITT, BEATRICE F., GORRIE, RACHAEL, and COCKBURN, T. AIDAN.
1951. ENCEPHALITIS IN MIDWEST. VI.—WESTERN EQUINE ENCEPHALOMYELITIS VIRUS ISOLATED FROM AEDES DORSALIS MEIGEN. Soc. Expt. Biol. & Med. Proc. 78: 289-290.

(305) THURMAN, ERNESTINE BASHAM, HAEGER, JAMES S., and MULRENNAN, JOHN A.
1949. THE OCCURRENCE OF AEDES (OCHLEROTATUS) THELCTER DYAR IN THE FLORIDA KEYS. Mosquito News 9: 171-172.

(306) ——— HAEGER, JAMES S., and MULRENNAN, JOHN A.
1951. THE TAXONOMY AND BIOLOGY OF PSOROPHORA (JANTHINOSOMA) JOHNSTONII (GRABHAM, 1905) (DIPTERA: CULICIDAE). Ent. Soc. Amer. Ann. 44: 144-157.

(307) TRAVIS, B. V., and MORTON, F. A.
1946. TREATMENT OF CLOTHING FOR PROTECTION AGAINST MOSQUITOES. N. J. Mosquito Extermin. Assoc. Proc. 33: 65-69.

(308) ——— MORTON, FRED A., and COCHRAN, J. H.
1946. INSECT REPELLENTS USED AS SKIN TREATMENTS BY THE ARMED FORCES. Jour. Econ. Ent. 39: 627-630.

(309) ——— and SMITH, CARROLL N.
1951. MOSQUITO REPELLENTS SELECTED FOR USE ON MAN. Jour. Econ. Ent. (Sci. Note) 44: 428-429.

(310) UNITED STATES DEPARTMENT OF AGRICULTURE, ENTOMOLOGY RESEARCH BRANCH.
1955. INSECTICIDES AND REPELLENTS FOR THE CONTROL OF INSECTS OF MEDICAL IMPORTANCE TO THE ARMED FORCES. U. S. Dept. Agr. Cir. No. 977, 91 pp., illus.

(311) UNITED STATES PUBLIC HEALTH SERVICE.
1951. MOSQUITO RECORDS FROM THE MISSOURI RIVER BASIN STATES. Survey Section, CDC. 93 pp. [Mimeographed.]

(312) VAN DINE, D. L.
1922. IMPOUNDING WATER IN A BAYOU TO CONTROL BREEDING OF MALARIA MOSQUITOES. U. S. Dept. Agr. Bul. 1098, 22 pp., illus.

(313) VANNOTE, ROBERT L.
1937. METHOD OF APPLYING THE LARVICIDE AS A REPELLENT. N. J. Mosquito Extermin. Assoc. Proc. 24: 11-15.

(314) VOGT, GEORGE B.
1947. SALINITY TOLERANCE OF ANOPHELES QUADRIMACULATUS AND HABITAT PREFERENCE OF A. CRUCIANS BRADLEYI. Jour. Econ. Ent. 40: 320-325.

(315) WALLIS, ROBERT C.
1954. NOTES ON THE BIOLOGY OF CULISETA MELANURA (COQUILLETT). Mosquito News 14: 33-34.

(316) WANAMAKER, JOHN F.
1944. AN IMPROVED METHOD FOR MOUNTING MOSQUITO LARVAE. Amer. Jour. Trop. Med. 24: 385-386.

(317) ——— CHAMBERLAIN, ROY W., and CARPENTER, STANLEY J.
1944. DISTRIBUTION OF CULEX PIPIENS IN THE SOUTHEASTERN UNITED STATES. Jour. Econ. Ent. (Sci. Note) 37: 106-107.

(318) WATSON, R. B., KIKER, C. C., and JOHNSON, H. A.
1938. THE ROLE OF AIRPLANE DUSTING IN THE CONTROL OF ANOPHELES BREEDING ASSOCIATED WITH IMPOUNDED WATERS. U. S. Pub. Health Serv. Rpts. 53: 251-263, illus.

(319) ——— and SPAIN, E. L., JR.
1937. STUDIES ON MALARIA IN THE TENNESSEE VALLEY. THE INFLUENCE OF PHYSIOGRAPHY ON THE OCCURRENCE OF BREEDING PLACES OF ANOPHELES QUADRIMACULATUS IN NORTHERN ALABAMA. Amer. Jour. Trop. Med. 17: 289-305, illus.

(320) WEATHERSBEE, ALBERT A., and ARNOLD, F. T., JR.
1947. A RESUME OF THE MOSQUITOES OF SOUTH CAROLINA. Tenn. Acad. Sci. Jour. 22: 210-229.

(321) ——— and ARNOLD, F. T., JR.
1948. A REVISION OF THE GENUS WYEOMYIA THEOBALD (DIPTERA, CULICIDAE) IN SOUTH CAROLINA. Tenn. Acad. Sci. Jour. 23: 249-250.

(322) WELCH, E. V.
1939. INSECTS FOUND ON AIRCRAFT AT MIAMI, FLA., IN 1938. U. S. Pub. Health Serv. Rpts. 54: 561-566.

(323) ———
1945. THE FINDING OF ANOPHELES ALBIMANUS WIED. AT WEST PALM BEACH, FLORIDA, (DIPTERA, CULICIDAE). Mosquito News 5: 145.

(324) WHITEHEAD, F. E.
1951. HOST PREFERENCE OF PSOROPHORA CONFINNIS AND P. DISCOLOR. Jour. Econ. Ent. 44: 1019.

(325) WILKINS, ORIN P., and BRELAND, OSMOND P.
1949. RECOVERY OF THE MOSQUITO, CULISETA INORNATA (WILLISTON) FROM DRY MATERIAL. Ent. Soc. Wash. Proc. 51: 27-28.

(326) ——— and BRELAND, OSMOND P.
1951. THE LARVAL STAGES AND THE BIOLOGY OF THE MOSQUITO ORTHOPODOMYIA ALBA BAKER (DIPTERA, CULICIDAE). N. Y. Ent. Soc. Jour. 59: 225-240.

(327) WILLIAMS, LOUIS L., JR.
1941. THE ANTI-MALARIA PROGRAM IN NORTH AMERICA. *In* Human Malaria, Amer. Assoc. Adv. Sci. Pub. 15, pp. 365-370, illus.

(328) ——— and COOK, S. S.
1927. PARIS GREEN APPLIED BY AIRPLANE IN THE CONTROL OF ANOPHELES PRODUCTION. U.S. Pub. Health Serv. Rpts. 42: 459-480, illus.

(329) ——— and LEGARE, A. E.
1928. LENGTH OF LIFE OF ANOPHELES QUADRIMACULATUS AFTER BEGINNING OF CONTROL OF PRODUCTION. South. Med. Jour. 21: 735-737, illus.

(330) WIRTH, WILLIS W.
1944. NOTES ON THE OCCURRENCE OF ANOPHELES GEORGIANUS KING IN LOUISIANA. Jour. Econ. Ent. (Sci. Note) 37: 446.

(331) ———
1945. THE OCCURRENCE OF CULEX (MELANOCONION) ELEVATOR DYAR AND KNAB IN FLORIDA, WITH KEYS TO THE MELANOCONIONS OF THE UNITED STATES (DIPTERA, CULICIDAE). Ent. Soc. Wash. Proc. 47: 199-210, illus.

(332) ———
1947. NOTES ON THE MOSQUITOES OF LOUISIANA. Jour. Econ. Ent. (Sci. Note) 40: 742-744.

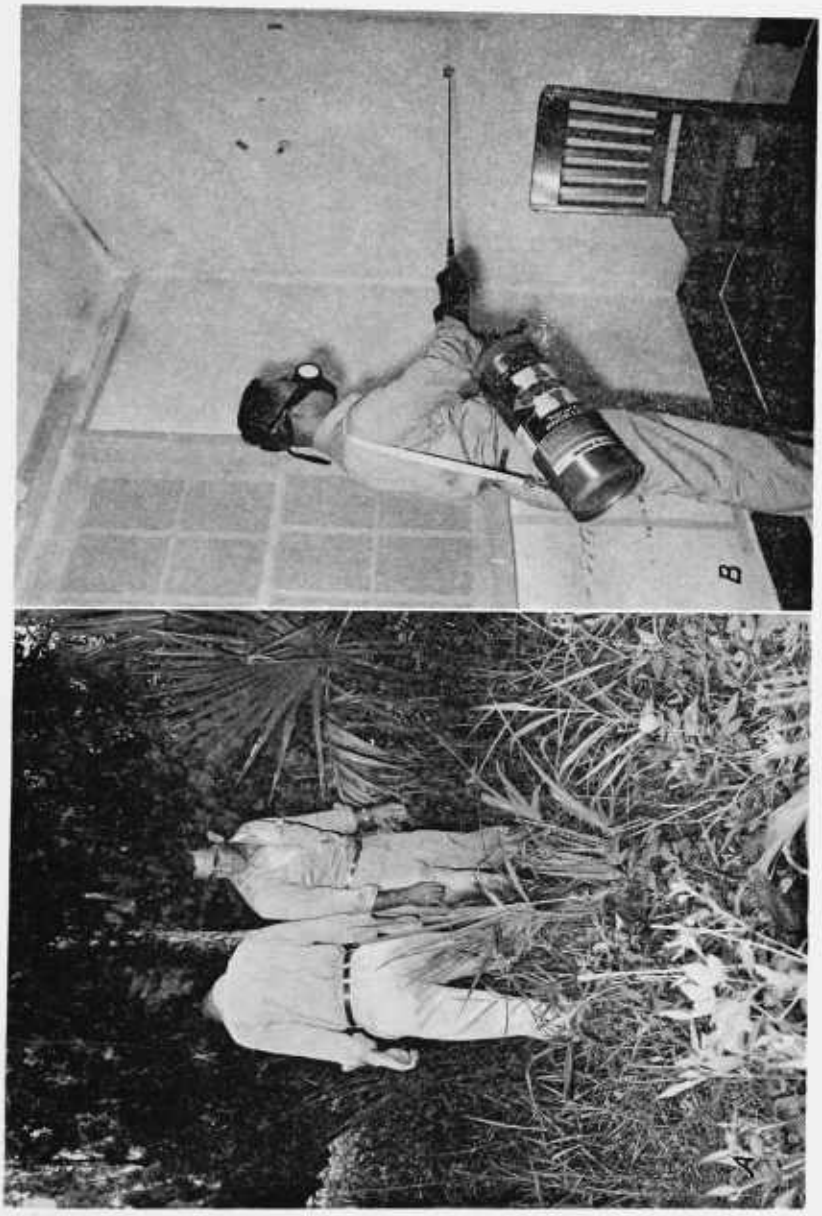
(333) WRAY, FRANKLIN C.
1946. SIX GENERATIONS OF CULEX PIPIENS WITHOUT A BLOOD MEAL. Mosquito News 6: 71-72, illus.

(334) YAMAGUTI, SATYU.
1952. ILLUSTRATED KEYS TO THE ADULT CULICINE MOSQUITOES OF AMERICA NORTH OF MEXICO WITH NOTES ON GENERAL MORPHOLOGY AND BIOLOGY OF GENERA. 48 pp., illus.

(335) ——— and LACASSE, WALTER J.
1951. MOSQUITO FAUNA OF NORTH AMERICA. Parts I-V. Office of the Surgeon, Hq., Japan Logistical Command. 629 pp.

(336) YEN, CHIA-HSIEN.
1938. STUDIES ON DIROFILARIA IMMITIS LEIDY WITH SPECIAL REFERENCE TO THE SUSCEPTIBILITY OF SOME MINNESOTA SPECIES OF MOSQUITOES TO THE INFECTION. Jour. Parasitol. 24: 189-205.

(337) YOUNG, FRANK N., JR., and CHRISTOPHER, WARREN N.
1944. UNUSUAL BREEDING PLACES OF MOSQUITOES IN THE VICINITY OF KEESLER FIELD, MISSISSIPPI. Amer. Jour. Trop. Med. 24: 379.

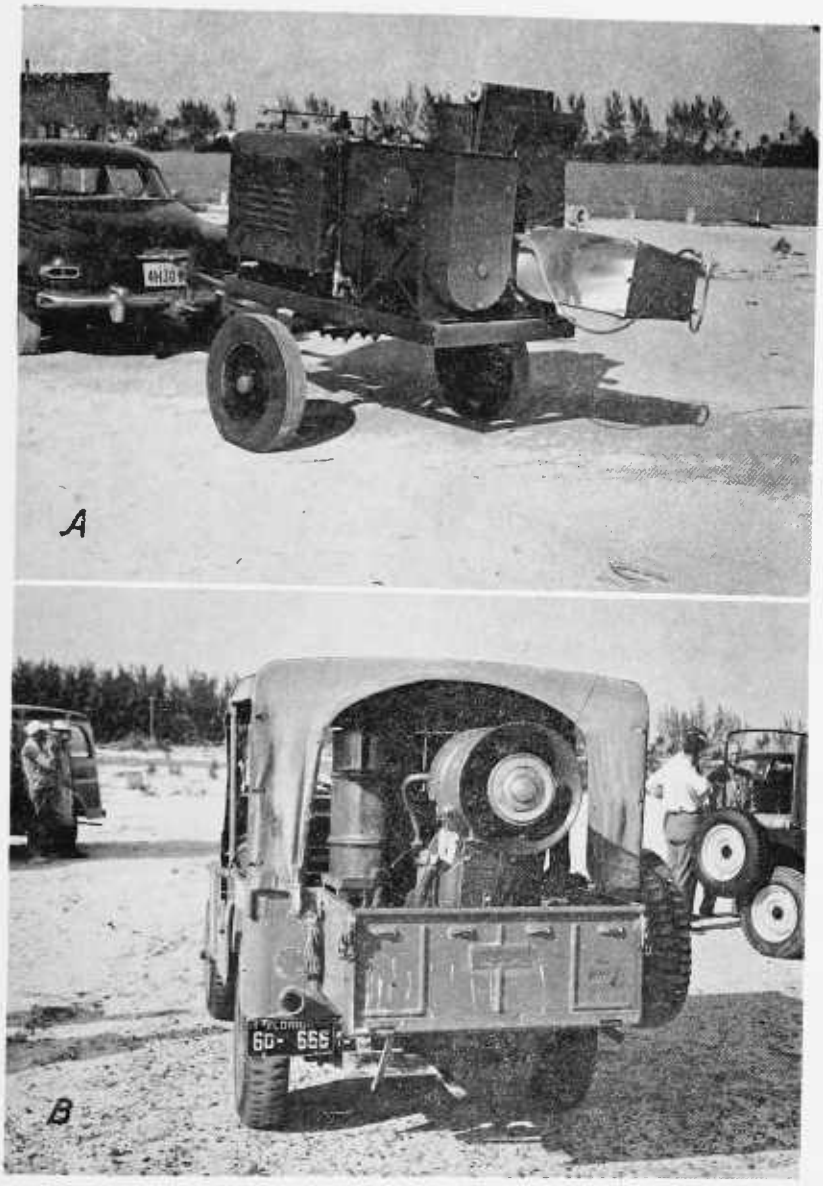


M & A 14066, M & A 14067

Plate 1.—*A*, Taking mosquito landing counts. *B*, Applying a residual spray with a pressure sprayer.

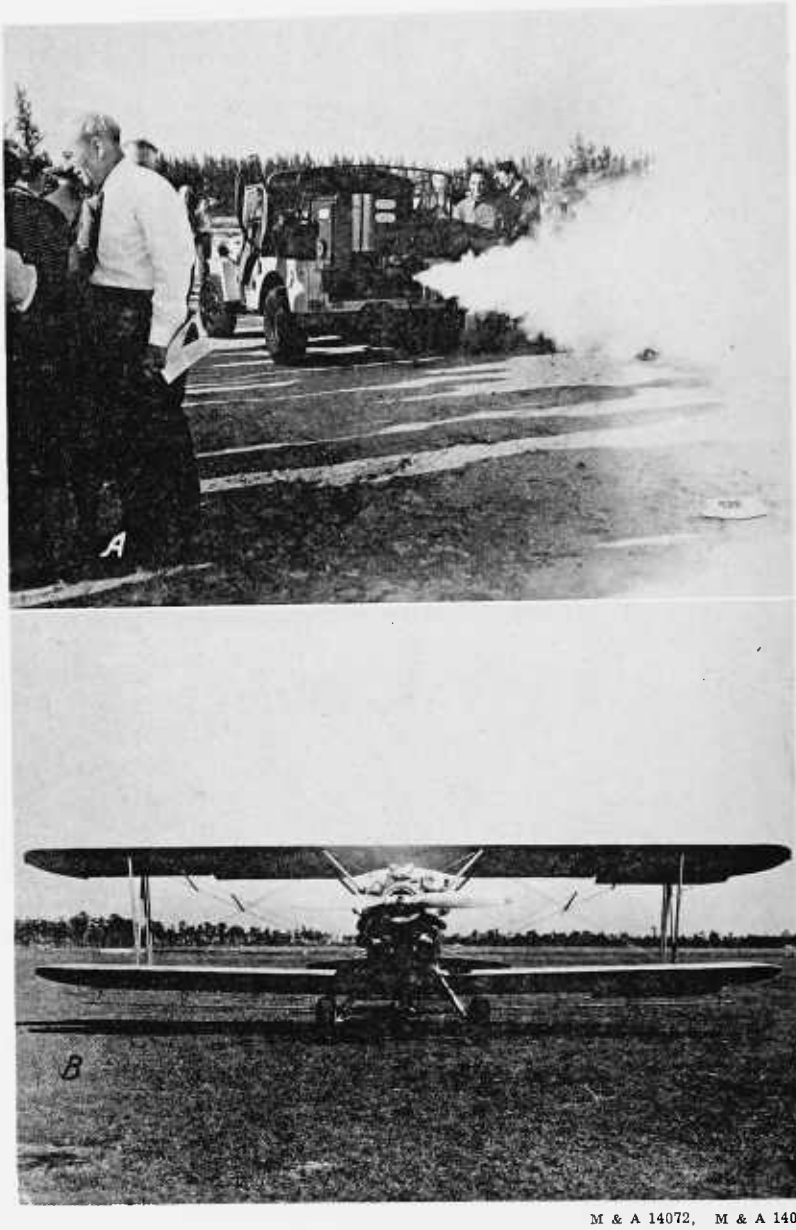
M & A 14068, M & A 14069

Plate 2.—*A*, A seasonal bayou overgrown with willows. *B*, A portion of the same bayou after clearing and impounding to eliminate *Anopheles* breeding.



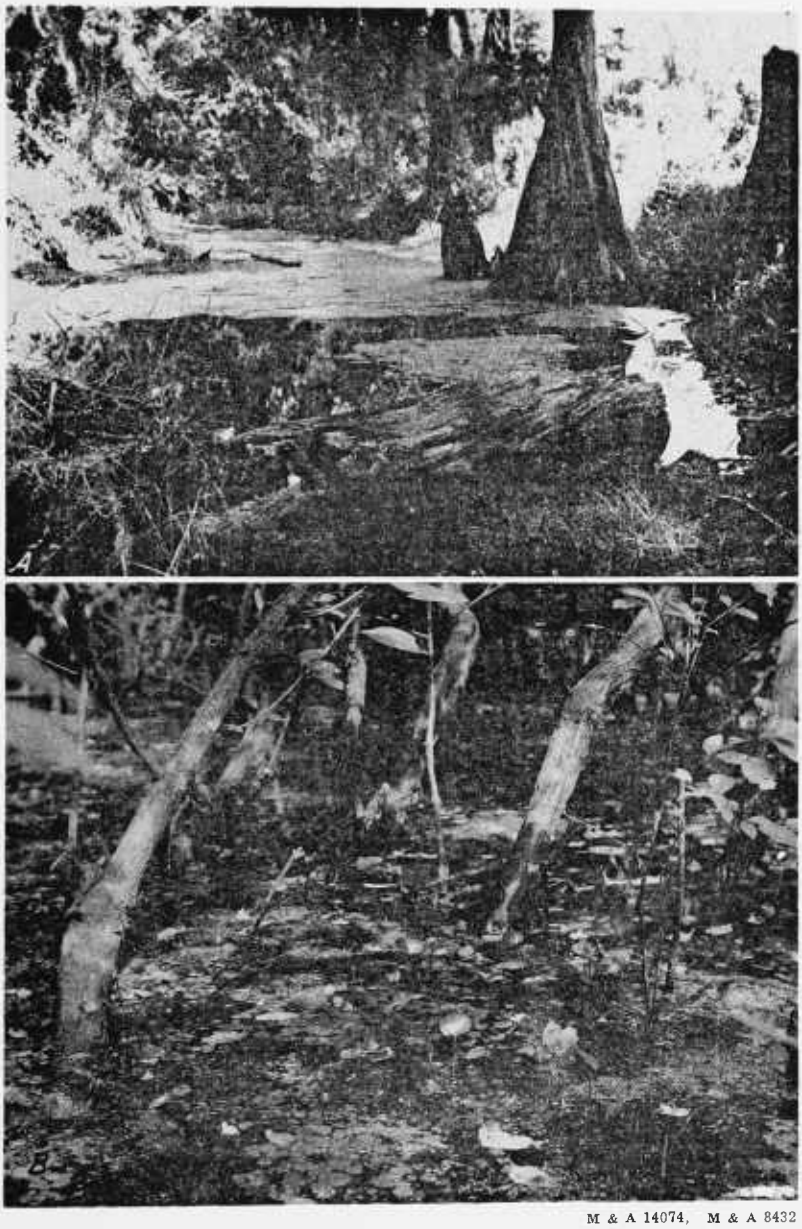
M & A 14070, M & A 14071

Plate 3.—*A*, Mist blower mounted on a two-wheel trailer. *B*, A microsol machine mounted in a jeep.



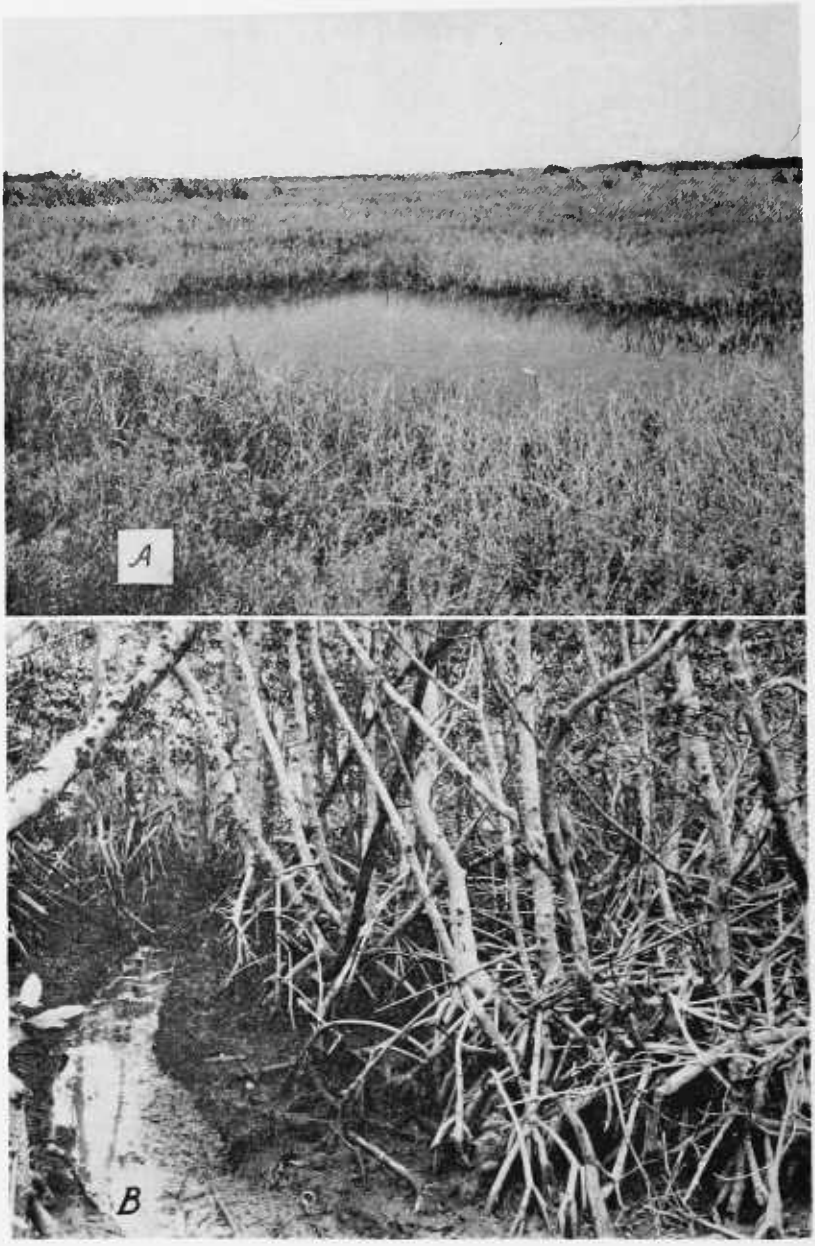
M & A 14072, M & A 14073

Plate 4.—*A*, Thermal fog generator mounted in a jeep. *B*, PT-17 plane equipped with underwing spray booms.



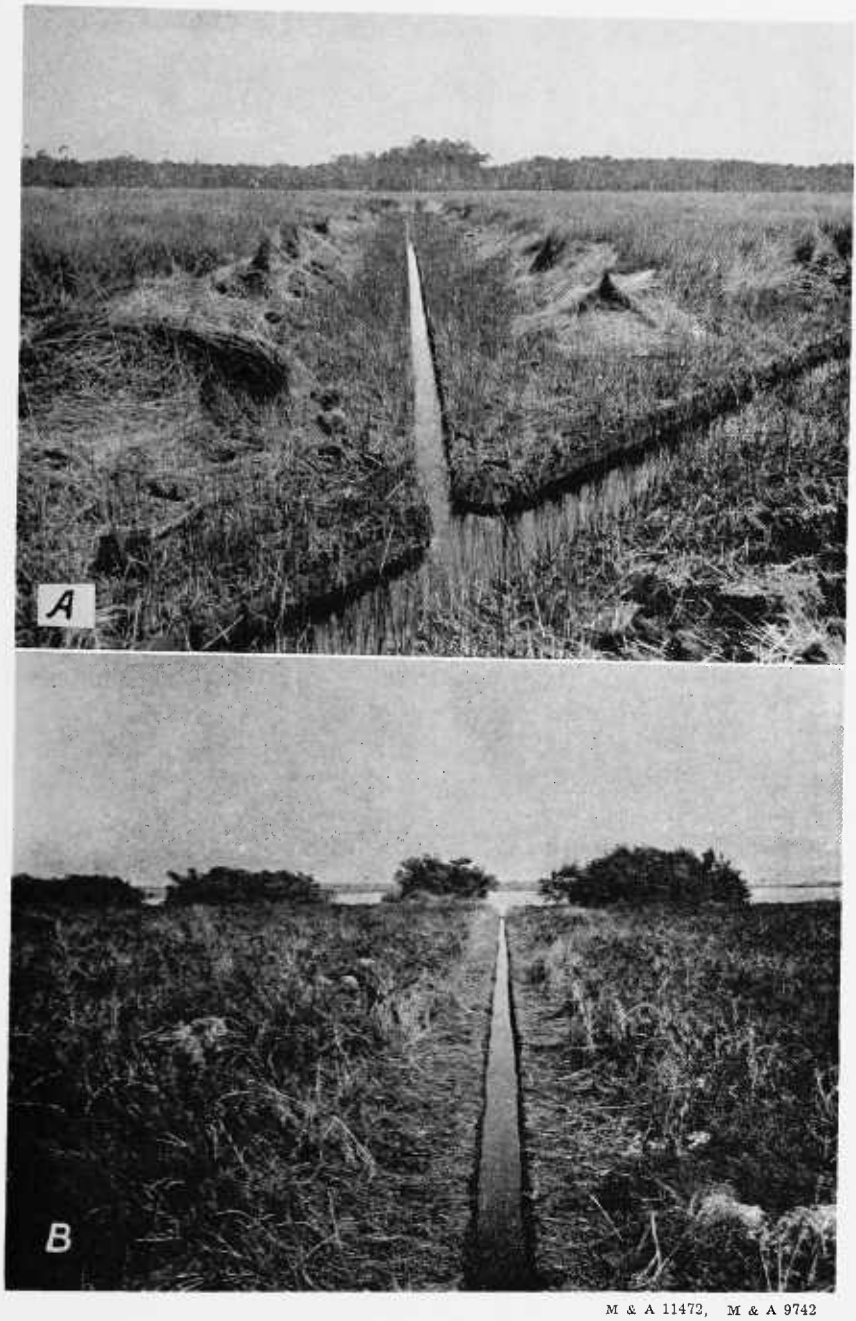
M & A 14074, M & A 8432

Plate 5.—*A*, *Anopheles* breeding pool in a cypress swamp. *B*, Water conditions favorable for breeding of *Anopheles quadrimaculatus*.



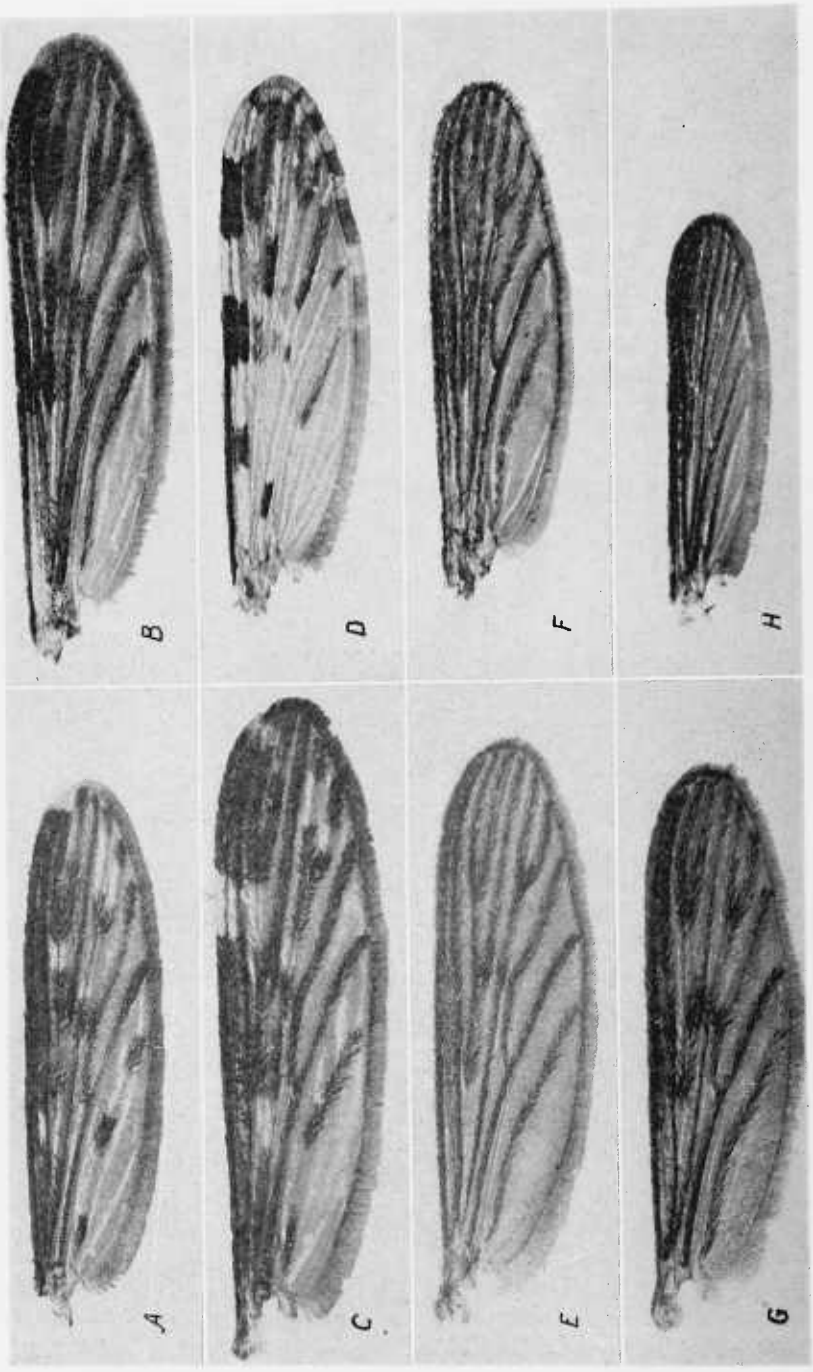
M & A 9815, M & A 14076

Plate 6.—*A*, A prolific breeding place of *Aedes taeniorhynchus* in a pickleweed (*Batis maritima*) marsh. *B*, Red mangrove (*Rhizophora mangle*) in a Florida marsh, showing the dense growth and characteristically divided base.



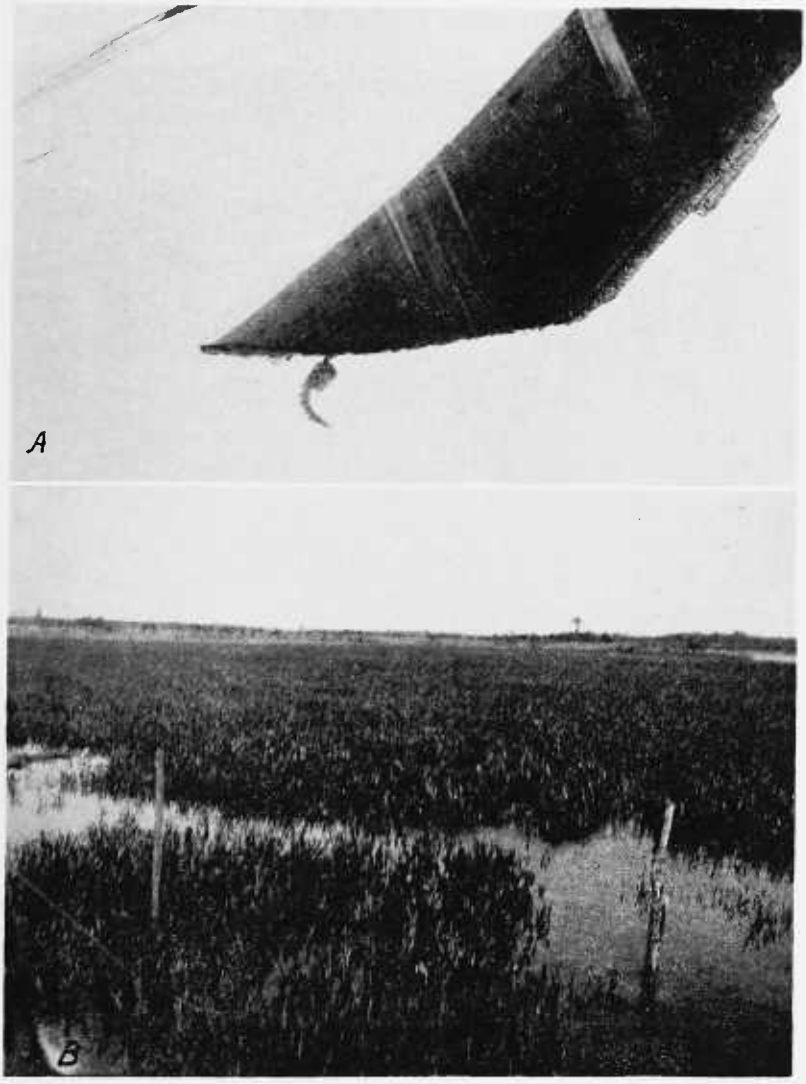
M & A 11472, M & A 9742

Plate 7.—*A*, A 30-inch main ditch and a 10-inch lateral in a *Juncus* marsh in North Carolina; *B*, A 30-inch ditch in a pickleweed (*Batis*) marsh in Florida.



M & A 14075,

Plate 8.—Wings of the typically Nearctic species of *Anopheles: A, crucians; B, freeborni; C, punctipennis; D, pseudopunctipennis: E, walkeri; F, atropos; G, quadrimaculatus; H, barberi.*



M & A 9007, M & A 9614

Plate 9.—*A*, A pupa of *Mansonia perturbans* attached to the cut stem of an aquatic plant. *B*, A breeding place of M. *perturbans*, a large shallow pond filled with pickerelweed *(Pontederia)*.

M & A 11083.

Plate 10.—A water-holding air plant (bromeliad) which serves as a breeding place for *Wyeomyia mitchellii* and *W. vanduzeei*.

INDEX

(Valid names are in roman type, synonyms in italics. Figures in bold-faced type indicate page on which the genus or species is described.)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1960—527552